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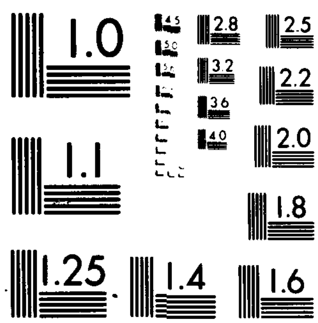


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# CIVIL PREPAREDNESS AND POST-ATTACK U.S. ECONOMIC RECOVERY: A STATE-OF-THE-ART ASSESSMENT AND SELECTED ANNOTATED BIBLIOGRAPHY

FINAL REPORT - VOLUME 1

Abe Feinberg

Contract No. DCPA01-78-C-0324
FEMA WORK UNIT NO. 4341-E

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## SUMMARY

This report contains an assessment of the state-of-the-art of modeling and analysis for civil preparedness and management of the post-attack U.S. economy. This evaluation was derived from a large volume of related literature. A selected annotated bibliography of over 100 entries follows a state-of-the-art assessment.

Literature areas reviewed included historical disasters, industry studies, post-attack viability, survival and economic recovery, and civil defense, both U.S. and Soviet. Some literature on modeling methods was researched. Modeling methods covered were input/output, econometrics, optimization, and system dynamics.

Analysis of the literature and current state-of-the-art revealed several key management aspects of the post-attack economy. These aspects were resource allocation and distribution, energy, information, communication, command and control ($C^3$), finance, social and behavioral response, and government authority. Most of these managerial aspects were found to have been neither thoroughly analyzed nor specifically modeled.

Assessing modeling needs, available modeling methods, and deficiencies in the state-of-the-art led to a recommendation for further development of system dynamics models for management of the U.S. post-attack economic recovery. System dynamics is suggested because of its flexibility, potential scope, and capabilities for handling non-linearities, dynamic effects, and soft items such as social and behavioral responses.

Critical issues recommended for further investigation include: analysis of the use of information, communication, and command and control ($C^3$) systems in post-attack survival and economic recovery management; incorporation of the impacts of mobilization and national security requirements on post-attack U.S. economic recovery; consideration of multiple regions with varying damage levels; analysis of social and behavioral factors; and evaluation of alternative civil preparedness policies. Taken together, these recommendations point toward analysis and assessment of alternative policies for civil preparedness and post-attack U.S. economic recovery.

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## PREFACE

This report has been written as part of Analytical Assessments Corporation's study of the management of the post-attack U.S. economy. Two other reports have been written covering other aspects of AAC's research on the management of the post-attack U.S. economy. They are:

> G. Hill and P. Gardiner, "Managing the U.S. Economy in a Post-Attack Environment: A System Dynamics Model of Viability," AAC-TR-9205/79, November 1979; and
>
> G. Quester, "Options for Accelerating Economic Recovery After Nuclear Attack," AAC-TR-9203/79, July 1979.

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The results of this review led to the development of a system dynamics model of the management of the U.S. economy reported on in Hill and Gardiner's report. The primary focus of this study is to determine if post-attack viability (or collapse) is automatic for a given system, or if management actions can influence the outcome. In investigating this problem, the approach focused on exploring the structure of a post-attack system for instabilities, identifying the processes that could lead to collapse, and then evaluating if and how alternative post-attack management policies can mitigate the effects of those instabilties.

At the conceptual level, the approach that was taken characterized a system's viability in terms of an inventories "race." Since the immediate post-attack period would be marked by a reliance on stockpiles and inventories to sustain the surviving population, the critical question was whether inventories would be depleted before the economy could replenish supplies by reorganizing initial production facilities. Additionally, the study attempted to determine how various types of systemic instabilities can affect this inventories race and how management actions can effectively overcome any debilitating effects that these instabilities might have on the ability of the nation to recover. These instabilities may appear due to the delays and uncertainties affecting such basic economic support systems as communication and transportation networks, organizational structures and resource allocation mechanisms.

A system dynamics model was constructed of a post-attack economy to study the management problems affecting these support systems in the immediate post-attack period. Through repeated simulation, the model was able to demonstrate the effects of potential instabilities on the performance of the economy and how alternative management policies could mitigate those effects. While the results should be qualified as being preliminary in the sense that this effort is a first pass at the problem, there is sufficient evidence to proceed with a more extended analysis. The evidence suggests that the issue of viability is greatly dependent on effective emergency preparedness policies and resource management actions. The simulation results from the model clearly indicate that viability is not automatic even if adequate productive capacities survive; the same system can produce both viability and collapse depending on the choice of policies and management strategies. If ineffective pre-attack and post-attack policies are followed, the potential for debilitating instabilities arising greatly increases and so, too does the potential for system collapse.

Quester's report is a companion piece to the two above studies. It starts with the conclusion of these two studies, as well as many other studies of post-attack recovery, that we are likely to fail to exploit to the fullest our potential for economic recovery following a nuclear attack because of failures in post-attack management in both the political and economic sectors. It also presumes that large-scale changes in peacetime arrangements will not win acceptance, so that the best hope for improvement is to look for more marginal adjustments in our continually evolving peacetime management systems, adjustments which might contribute substantially to post-attack recovery at little peacetime cost.

In addition, Quester's report reviews general technological trends in key areas with regard to whether they will

tend to make the government reorganization problems easier or harder. Inferences are drawn about relatively inexpensive pre-attack actions, based on exploiting favorable technological trends, which could be taken to make the post-attack management problems more tractable. The report is optimistic, in that it believes that a number of such adjustments deserves to be explored. The post-attack considerations addressed include making government more effective in bringing about economic recovery <u>and</u>, very importantly, making sure that government continues as government, i.e., that we do not sink into anarchy.

This analysis in Quester's report is intended to put upon the table a number of new ideas worthy of further consideration. It is not within the scope of this analysis to evaluate these ideas. Consequently, it may turn out that some of these ideas do not stand up to the scrutiny of further exploration. Nevertheless, this report serves the important purpose of providing a rich menu of management policies which should be evaluated further.

# ACKNOWLEDGEMENTS

This review of the state-of-the-art of civil preparedness and post-attack economic recovery has drawn greatly from literature cited and quoted herein. To the authors of those documents, this report owes much.

I am especially indebted to Dr. Howard M. Berger, of Analytical Assessments Corporation, first for his insights and patient counsel, and second for his December 1978 report sponsored by the Defense Nuclear Agency, A Critical Review of Survival and Recovery After a Large-Scale Nuclear Attack. About 20 of the 110 annotated bibliographic entries in this report are reproduced from Dr. Berger's review.

I would also like to thank George Divine, now at the Federal Emergency Management Agency (formerly at the Defense Civil Preparedness Agency) for his helpful suggestions, recommendations of pertinent literature, and support.

My thanks are due for comments and discussions with Analytical Assessments colleagues Drs. Peter Gardiner, Gary Hill, W. Andrew Terrill, Abraham Wagner and Carol Wagner. Considerable appreciation is owed to Karen Muranaka, whose diligent typing, editing and retyping, with the assistance of Dee DeLuca, enabled this report to be completed.

The aid of those cited above notwithstanding, responsibility for the contents of this report rests solely with the author.

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## OVERVIEW

The overall objective of this state-of-the-art review has been to obtain insights and suggestions for the developing U.S. civil preparedness program, with emphasis on those civil preparedness measures which will make post-attack economic recovery more swift and more certain.

In pursuit of the overall objective just stated, two tasks were carried out. The first was an assessment of the state-of-the-art of modeling and analysis involving civil preparedness and post-attack economic recovery. This included the modeling and analysis efforts to date in pertinent areas plus a review of the status of U.S. civil preparedness. The second task was the preparation of a selected annotated bibliography for use by those working in the fields of civil preparedness and post-attack economic recovery. These tasks were aimed at providing guidance for the U.S. civil preparedness program and for modeling and analysis which will aid in the development of the U.S. civil preparedness program.

As a result of these tasks, the report contains an assessment of the state-of-the-art of modeling and analysis for civil preparedness and management of the post-attack U.S. economy. This evaluation was derived from a large volume of related literature. A selected, annotated bibliography of over 100 entries follows the state-of-the-art assessment.

Literature areas reviewed included historical disasters, industry studies, post-attack viability, survival and economic recovery, and civil defense, both U.S. and Soviet. Some literature on modeling methods was researched. Modeling methods covered were input/output, econometrics, optimization, and system dynamics.

Analysis of the literature and current state-of-the-art revealed that several management aspects of the post-attack economy are crucial. These aspects were resource allocation and distribution, energy, information, communication, command and control ($C^3$), finance, social and behavioral response, and government authority. Most of these managerial aspects were found to have been neither thoroughly analyzed nor specifically modeled.

Assessing modeling needs, available modeling methods, and deficiencies in the state-of-the-art has led to a recommendation for further development of system dynamics models for management of U.S. post-attack economic recovery. System dynamics is suggested because of its flexibility, potential scope, and capabilities for handling non-linearities, dynamic effects, and soft items such as social and behavioral responses.

Critical issues recommended for further investigation include: analysis of the use of information, communication, command and control ($C^3$) systems in post-attack survival and economic recovery management; incorporation of the impacts of mobilization and national security requirements on post-attack U.S. economic recovery; consideration of multiple regions with varying damage levels; analysis of social and behavioral factors; and evaluation of alternative civil preparedness policies. Taken together, these recommendations point toward analysis and development of a comprehensive but not cumbersome model for the assessment of alternative policies for civil preparedness and post-attack U.S. economic recovery.

## TECHNICAL REQUIREMENTS FOR MODELING AND ANALYSIS

In simple terms the two basic modeling needs for post-attack recovery models which are suitable for evaluating alternative

civil preparedness measures are that they be useful and relatively inexpensive. The latter is easier to define and measure; statement of recovery modeling's objective would be to maximize usefulness to civil preparedness planners subject to meeting development cost restrictions. Although hard to define, some aspects of model usefulness can be listed as follows:

1. Decision/Policy Orientation
2. Flexibility
3. Realism
4. Comprehensiveness
5. Speed of Response

If an economic recovery model is to actively help civil preparedness planners, it must afford them the opportunity to examine alternative decisions and policies. Thus, the model must be oriented toward that end. It should also provide insights and directions for civil preparedness.

The useful model must be flexible as well. It must be able to incorporate new aspects without undue difficulty, including the managerial aspects described in Section 1.9 of this report. Also, it should be capable of handling differing levels of detail in separate portions of the model. Thus, aspects introduced into the model would not always have to be as detailed as well-structured aspects.

The realism of a post-attack recovery model is a very difficult attribute to assess. Yet, there are several items of realism not widely incorporated into prior models that would make them more realistic. These items include: nonlinear and dynamic relationships; the management aspects cited before; separate

time phases for survival, reorganization and recovery; and the allowance for multiple regions with varying damage levels and post-attack transfers of people and goods.

The comprehensive model must include all significant aspects that could impact model results and thus inferences drawn from these results. The drive toward comprehensiveness must be tempered by the need for quick response, i.e., of development and of execution. Including too much may delay both the model's initial availability as well as its response time when operational.

## CURRENT STATUS OF MODELING AND ANALYSIS

The great majority of economic recovery analyses that have been reviewed are based on input/output models. The reason that so many studies using input/output models have been reviewed is a direct result of the fact that nearly all quantitative analyses of economic recovery written since the early 1960's are based on such models. A few of the studies reviewed use linear programming models to optimize an objective function, but even these models frequently use input/output submodels to keep track of interindustry flow. In a few studies, econometric models are used in an attempt to model the dynamic aspects of recovery. Some other modeling approaches have been suggested in the studies reviewed, but none have been carried much further than the conceptual stage except for the recently started efforts using system dynamics.

The input/output models and econometric models that normally are used to analyze post-attack recovery are necessarily based upon

assumptions about the pre-attack relationships between different parts of the economy. If these relationships are relatively unchanged, we can get an adequate estimate of post-attack capability simply by examining the results of a damage assessment model. In that case, we do not need the more detailed macroeconomic models. Those cases where we do need more than a simple damage assessment model are exactly those cases in which the vast majority of the present models do not apply, namely those in which there is a significant change in demand.

It is concluded that, in spite of the large number of models that have been developed for the analysis of economic recovery, adequate models do not yet exist. It is also concluded that it does not appear that further refinement of existing models will significantly improve their usefulness. Different approaches appear to be needed.

The greatest promise for a model of economic recovery to incorporate some of the aspects needed lies in the area of system dynamics. This modeling method and its potential for economic recovery modeling with linkage to civil preparedness is discussed at length in Section 1.11 of this report.

The analysis of the current civil defense program as well as alternative postures discussed in this report (see Section 1.7) deal almost exclusively with the protection of people. The major issue still remains whether the U.S. civil defense program should protect things other than people. One issue that has been addressed in some of the recent civil defense debates is that protection of industry. No convincing analysis is available which will tell us how much and what kind of industry, if any, should be protected, nor is there any consensus on the feasibility of doing so. But a larger issue about protecting more

than just people remains. If we accept the broad definition of civil defense, there is a long list of organizational capabilities that must be preserved. There is no reason to believe that preserving these capabilities would be inordinately expensive. Yet very few of the civil preparedness measures that have been analyzed address the preservation of these capabilities.

## EVALUATION OF THE CURRENT POSITION

This study has revealed several important deficiencies in the present state-of-the-art of modeling and analysis involving civil preparedness and post-attack economic recovery. To summarize these deficiencies, it appears that a comprehensive, decision-oriented, realistic and flexible model is not yet extant, nor has the analysis related to such a model been done. The bulk of the research on civil preparedness and post-attack economic recovery has been fragmented, rather than wholistic, as illustrated by the major topic headings of this report. In addition, many aspects that are difficult to quantify and support with data have been neglected.

To discuss some of these dificiencies more specifically, a good place to begin is the heretofore limited scope of the state-of-the-art. That is, since analysis and modeling linking civil preparedness and post-attack economic recovery have been lacking, it has been difficult to quantitatively assess the impact of alternative civil preparedness policies on post-attack economic recovery. With this lack, costs of civil preparedness have been far easier to quantify than benefits, thus limiting comparisons of civil preparedness alternatives to civil preparedness costs and post-attack casualties.*

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*For example, see J. Pettee et al., PONAST II, Office of Civil Preparedness, 1972, or Roger J. Sullivan et al., Civil Defense Needs of High Risk Areas of the United States, Final Report SPC 409, System Planning Corporation, Arlington, VA, March 1979.

Another side of the limitation in scope has been the difficulty in varying attack scenarios. Without this capability, most studies have been limited to attacks comprised of a single salvo fired over a short time span. There has been little effort directed toward protracted attacks or exchanges involving multiple attacks.

A concomitant result of the limitation in scope of the state-of-the-art is the absence of a decision-orientation for analysis of civil preparedness and post-attack economic recovery. Most studies and models have been descriptively oriented, i.e., given a set of inputs and assumptions, to find what is likely to occur. In contrast, a decision-oriented study would be directed toward the comparision of alternatives for management actions or the identification of the best of competing alternatives.

Although generally due to resource limitations and choice of modeling approach, the lack of realism in the analyses and models reviewed has several facets to it. One of these is the omission of significant management aspects of post-attack economic recovery. Some of these management aspects are information, communication, command and control ($C^3$) systems, and financial systems. Another is the omission of "soft" aspects such as behavioral and social responses. The post-attack response of people to government requests is a pertinent example of such an aspect. The third facet of the lack of realism in the modeling efforts reviewed is that of oversimplifying assumptions such as linearity and static time frame. More realistic modeling efforts would permit both nonlinearities and dynamic effects to be incorporated.

The final area of deficiencies in the state-of-the-art concerns the lack of flexibility of prior models. This rigidity has

made reactions to changing circumstances quite slow, with responses to inquiries considerably delayed.

The improvements suggested for the state-of-the-art of modeling and analysis for civil preparedness and post-attack economic recovery are directed toward remedying the deficiencies just cited. Thus, suggested state-of-the-art improvements are modeling and analysis directed toward the development of a comprehensive, decision-oriented, realistic and flexible investigative tool for study of civil preparedness and post-attack recovery.

Perhaps most important, yet most difficult, would be the development of a model that linked civil preparedness and management of the post-attack economy. Such a model should be decision-oriented, i.e., allow the assessment of civil preparedness and post-attack management alternatives. It should be realistic without being cumbersome. Elements of realism to be included are management aspects and social and behavioral aspects as described in the preceding section. Also, to be realistic, a model should permit nonlinearities and dynamic responses.

Model flexibility should be enhanced to easily permit changes in assumptions and quick responses to inquiries.

In order to model some of the hard to quantify aspects such as social and behavioral responses, some additional basic research on these responses in crises should be done. Recent disasters that could be examined for insights into human behavior during disaster are the Three Mile Island nuclear power plant failure of March 1979 and the Alabama, Mississippi and Florida Gulf Coast destruction of Hurricane Frederic in September 1979. Of particular interest is behavior in regard to evacuation from the disaster area.

Another improvement in state-of-the-art modeling of management of post-attack economic recovery would be the capability of modeling several regions with varying damage levels so that transactions between regions could be studied. Post-attack interactions between regions has not been explored via modeling.

The suggested state-of-the-art improvements involving modeling could be carried out by continued development of system dynamics models begun during the 1979 Fiscal Year for analysis of post-attack economic recovery and civil preparedness. The system dynamics models could be developed by progressively increasing their complexity to accommodate the improvements suggested here.

After reviewing the literature on civil preparedness and post-attack economic recovery, describing management aspects, detailing modeling needs and modeling methods available, listing deficiencies and suggested improvements in the state-of-the-art, it appears that system dynamics should be selected as the central modeling approach. Although there are many reasons for this choice, most are encompassed by the general statement that system dynamics, of the modeling methods reviewed, best meets the needs of modeling civil preparedness and post-attack economic recovery.

Perhaps the most important single reason for the choice of system dynamics is its flexibility. This flexibility is manifested in the capability of permitting varying levels of detail in different portions of the model. Detail can be extensive where research interest is intense while a higher level of aggregation can be used where interest is less. Also, system dynamics can handle multiple geographic sectors or regions,

each with its own degree of damage. This is an important capability for evaluating post-attack resource allocation policies, and an improvement over input/output models which do not have regional submodels.

The flexibility of system dynamics that permits varying the level of detail in the model allows investigations of model structure without requiring large volumes of data. This advantage of system dynamics is due to its process orientation as opposed to data orientation.

A feature of system dynamics that follows from its allowance for dynamic effects is the capability of incorporating delays. Delays that could be modeled include delays in physical movement, management decisions, communications, and organization.

It is suggested here that system dynamics be selected as the central modeling approach. It may well be desirable to employ other methods for determining the inputs to the system dynamics model or assessing the outputs from it. For example, an optimization model may be useful for selecting civil preparedness options to be input to the system dynamics model. Further, a decision analysis model could be used to rank post-attack management policies based on results output from the system dynamics model. In such cases, it would not be onerous to link the central system dynamics model with the other model segments.

## FUTURE RESEARCH EMPHASIS

There are many issues in the subject area that could benefit from further analysis and model development. These issues include a variety of investigations of alternative civil preparedness and emergency management policies and post-attack economic

recovery. These suggested investigations, involving both analysis and further model development, are discussed in turn.

First, continued analysis is needed of the use of information, communication, command and control ($C^3$) systems in post-attack survival and economic recovery management. Post-attack management will need good information to make good decisions and carry out policies, yet the post-attack information and $C^3$ system is likely to seriously weaken unless protection of the system is undertaken. Thus, further research should test the concept of a hardened emergency information and $C^3$ system that could be used for a variety of disaster situations as well as for post-nuclear attack analysis. Such an information and $C^3$ system should be incorporated into post-attack economic recovery modeling efforts so that the impact of the emergency information and $C^3$ system on post-attack recovery can be assessed.

Another important task for emphasis is further determination of the scope of post-attack economic management problems. This study could be carried out by analysis and development of a model designed to assess the effects of alternative post-attack resource management policies. Resource management here should be taken in a very general sense to include transportation, human and financial resources as well as the more obvious stocks of raw materials, goods, equipment, buildings and energy.

The analysis of post-attack economic recovery should incorporate the impacts of both mobilization and post-attack national security requirements. This could be accomplished by further analysis and inclusion of pre-attack mobilization and post-attack national security requirements, i.e., police and military needs, into an extended post-attack economic recovery model.

Continued research on civil preparedness and post-attack economic recovery should incorporate additional social and psychological

factors for greater realism in analysis and modeling. Factors to be investigated should include: responsiveness to government requests such as those to evacuate or to share limited resources; and behavior and productivity in times of severe dislocation and stress. Factors such as these would have a significant impact on post-attack recovery.

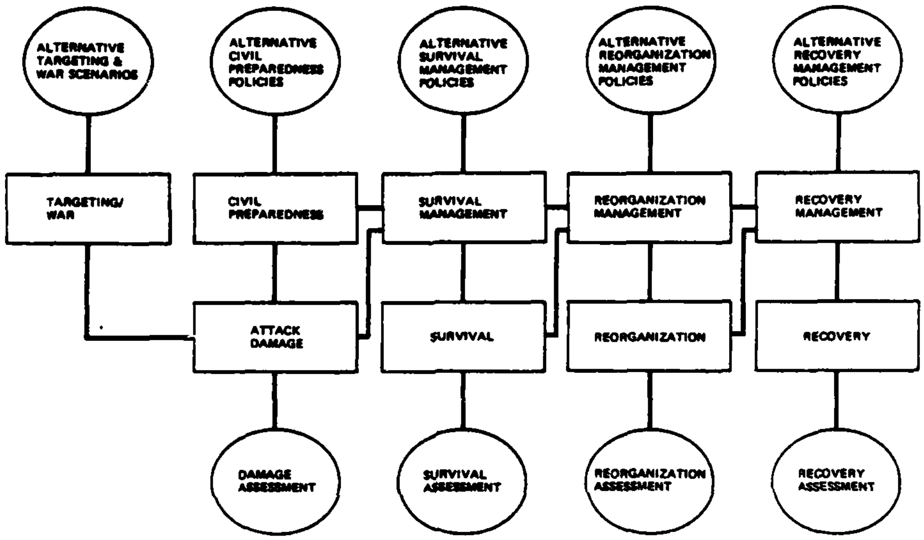
In order to broaden the spectrum of situations the post-attack recovery model can accommodate, the analysis and modeling efforts should be extended to encompass a variety of targeting and attack scenarios. An important scenario that has received little attention heretofore is protracted war. Targeting possibilities for study include counter-force, counter-value, counter-leadership, counter-recovery, and selective targeting, plus mixed strategies.

Another extension to the model should allow the testing and ranking of alternative civil preparedness policies. Candidate policies for stockpiling, post-attack resource allocation, information and communication, command and control, and pre-attack hardening and mobilization could be assessed and ranked in order of preference. This effort would reveal top-ranked candidate policies by considering resources used, strategic economic and social benefits, and implementation difficulty.

Taken together, these recommendations point toward analysis and development of a comprehensive but not cumbersome model for the assessment of alternative policies for post-attack economic recovery. The diagram of such a model's key time phases is shown in Figure 1. Alternative input scenarios and policies are shown at the top of the diagram, while assessmemt of damage and the post-attack phases are displayed across the bottom. Future modeling and analysis efforts should continue to look

FIGURE 1

DIAGRAM OF AN ADVANCED POST-ATTACK RECOVERY MODEL WITH ALTERNATIVE POLICY INPUTS AND ASSESSMENT OF RESULTS




for significant interactions between civil preparedness and post-attack management policies and post-attack economic recovery. A more comprehensive effort would be able to consider a wider range of possible difficulties and a broader spectrum of aids to recovery.

## POSSIBLE IMMEDIATE APPLICATIONS OF RESEARCH RESULTS

The research suggests that two systems for use in emergency management situations should have the highest priority for development. The first is an information, communication, command and control ($C^3$) system for the management of resources during emergencies. Needless to say, the system should be survivable.

The resources on which information would be needed should include human and financial resources as well as the more customary equipment, facilities and materials. The capability of management in emergencies will be very sensitive to the function of its information and $C^3$ system and priority should be placed on the development of such systems.

The second system suggested for priority development is an emergency energy management system. The literature reviewed for this study many times pointed towards energy as a critical factor in post-attack economic recovery. Recent events have shown how sensitive the peacetime economy is to energy supply problems. Perhaps an emergency energy management system designed to meet peacetime requirements could, with the proper attention to survivability, also be used for post-attack energy management.

# SECTION I

# STATE-OF-THE-ART ASSESSMENT

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## 1.1 LESSONS FROM HISTORICAL DISASTER LITERATURE

As a point of departure for studying economic recovery following a nuclear attack, several studies of historical disasters were reviewed. Some disasters covered in these studies were localized disasters, while others were disasters on a national scale. Some of the disasters were caused by nature, others by wars.

A common theme appears in these studies. This theme is that the economic recovery of the disaster area follows in a suprisingly short period of time if a large portion of the population survives and if they can obtain food and other essentials for continued survival.

The economic recovery theme described above was written over a century ago by John Stuart Mill in one of his "fundamental propositions on capital."* Mill wrote:

> This perpetual consumption and reproduction of capital affords the explanation of what has so often excited wonder, the great rapidity with which countries recover from a state of devastation; the disappearances, in a short time of all traces of the mischiefs done by earthquakes, floods, hurricanes, and the ravages of war. An enemy lays waste a country by fire and sword, and destroys or carries away nearly all the moveable wealth existing in it: all the inhabitants are ruined, and yet in a few years after, everything is much as it was before. This *vis medicatrix naturae* has been a subject of sterile astonishment, or has been cited to exemplify the wonderful strength of the principle of saving, which can repair such enormous losses in so brief an

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*John Stuart Mill, Principles of Political Economy, Vol. I, 5th London edition, D. Appleton and Company, New York, 1920, pp. 108-109.

interval. There is nothing at all wonderful in the matter. What the enemy have destroyed, would have been destroyed in a little time by the inhabitants themselves: the wealth which they so rapidly reproduce, would have needed to be reproduced and would have been reproduced in any case, and probably in as short a time. Nothing is changed, except that during the reproduction they have not now the advantage of consuming what had been produced previously. The possibility of a rapid repair of their disasters, mainly depends on whether the country has been depopulated. If its effective population have not been extirpated at the time, and are not starved afterwards; then, with the same skill and knowledge which they had before, with their land and its permanent improvements undestroyed, and the more durable buildings probably unimpaired, or only partially injured, they have nearly all the requisites for their former amount of production. If there is as much of food left to them, or of valuables to buy food, as enables them by any amount of privation to remain alive and in working condition, they will in a short time have raised as great a produce, and acquired collectively as great wealth and as great a capital, as before; by the mere continuance of that ordinary amount of exertion which they are accustomed to employ in their occupations. Nor does this evince any strength in the principle of saving, in the popular sense of the term, since what takes place is not intentional abstinence, but involuntary privation.

The historical disaster studies reviewed provide support for Mill's theme that a surviving population with food "will in a short time have raised as great a produce, and acquired collectively as great wealth and as great a capital, as before." Also, the historical disaster studies contain examples of the complementary theme that areas with populations destroyed do not recover.

In 1963, Hirshleifer investigated the economic characteristics of several major disasters and recoveries of relatively modern

times.* He reviewed disasters of both localized and national extent. His desired objective was that his study of actual disasters and recoveries would yield elements of concreteness useful to those studying hypothetical disasters. He recognized that no historical disaster for which good data were available is quite comparable to all out nuclear war, but suggested that the scale of damage of the historical disasters might be comparable to that of limited nuclear exchanges.

Hirshleifer covered both localized calamities such as bombing attacks or volcanic eruptions, and catastrophes of national scope such as war or famine. The localized disasters were usually swift to impact while those of national scope generally were gradual in their onset.

The local disaster studied by Hirshleifer included the San Francisco earthquake and fire of 1906 and the World War II bombings of Hamburg, Hiroshima, and Nagasaki. Most of the local disaster studies emphasized psychological aspects of people in the affected area. Of those people, Hirshleifer wrote:

> In general, it has been found that the "disaster syndrome" displayed by a population suddenly struck by disaster does not include the wild, asocial behavior described by the more lurid popular writers on such themes. Panic does not ordinarily occur. Survivors first reorient and extricate themselves, and then their families. Some, even when seriously injured themselves, assist others. If there is reason to fear another hazard (explosion, spreading fire, renewed bombing, etc.), there may be hasty flight. All this is rational behavior. Others

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*Jack Hirshleifer, Disaster and Recovery: A Historical Survey, RAND Corporation Memorandum RM-3079-PR, April 1963.

> seem to become temporarily stunned or apathetic, in which condition they will respond to direction but are incapable of independently useful action. In the immediate postimpact period, a strong feeling of community identification is generated, promoting cooperative and unselfish efforts toward repair and relief activity. Gradually, however, this stimulus wears off, after some days or weeks, and concern over unfairness of relief distribution and the like typically leads to considerable recriminations as a more normal society is restored.*

For the people outside the local disaster area, but in the support area, the behavior was described as follows:

> A very marked psychological pattern, the "counter-disaster syndrome," typically takes place in the support area, outside the impact zone of the disaster. The crisis calls forth an outburst of generous assistance, both personal and material, from this zone. Volunteer rescuers converge upon the disaster area; food and medicines are freely contributed; refugees are welcomed in reception areas. For many smaller disasters, the material support has been so great as to exceed emergency needs. Some time later, however, a reaction may set in, leading to bad relation between victim and support populations and accusations of ingratitude.**

Behavioral effects on the leadership and essential workers of the disaster area often involve abandonment of their posts to see to the safety of their own families. This abdication of pre-disaster leadership often led to the rise of new leaders or the entrance of leaders from the support area.

The perhaps unexpectedly rapid economic recovery of a localized disaster area was well illustrated by Hiroshima following the 6 August 1945 atomic bombing. Deaths from the bombing were

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* Ibid, p. 6.

** Ibid, p. 6.

estimated at 80,000 of the pre-attack population of 300,000. About 70 percent of the buildings in Hiroshima were destroyed compared with around 27 percent of the population. Injured survivors about equalled fatalities. People who fled the area the day of the attack began returning within 24 hours, and by November, the city population was back up to 140,000.

Hirshleifer describes Hiroshima's recovery with some very specific event dates.

> In the recuperation phase, it is worth noting that the air-burst bomb generally left underground utility networks intact. The gas producing plant and water pumping station survived, but destruction of gas-holders prevented service and lack of electricity stopped the water supply. Sewers were undamaged, but sewer pumping stations were inoperative. On August 7, power was generally restored to surviving areas, and through railroad service commenced on August 8. Telephone service started on August 15. Hiroshima was also not a dead city. The U.S. Strategic Bombing Survey reported that plants responsible for three-fourths of the city's industrial production could have resumed normal operations within 30 days (the newer and larger plants in Hiroshima were on the outskirts of the city, and both physical premises and personnel generally survived). By mid-1949, the population had grown to over 300,000 once more, and 70 percent of the destroyed buildings had been reconstructed.*

As Hirshliefer observed, a key element in the recovery of localized disaster is behavioral. Namely,

> The repeatedly demonstrated willingness of populations to put out extraordinary efforts with an exceptional degree of unselfishness in the crisis period is a crucial element in making recovery possible.**

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* Ibid, p. 13.

** Ibid, p. 14.

National scale disasters analyzed by Hirshleifer were: war communism in Russia 1917-21, the American Confederacy from 1861-65, and post-World War II Japan and Germany. His study of the economic collapse of the Confederacy led to the conclusion that the proximate course of this collapse was the breakdown in transportation. Thus, "towards the end of the war, resources and stocks of goods lay everywhere useless and subject to looting and deterioration, while the armies and factories were unable to secure vital materials."*

From his studies of these national scope disasters, Hirshleifer concluded:

> The experiences reviewed all displayed one or another variant of what seems to be a characteristic organizational phenomenon in disaster--the breakdown of the money-food trade between cities and countryside. Inflation leads to price controls, price controls to shrinkage of food deliveries, and shrinkage of deliveries to imposition of quotas on farmers, and often, to military collection of crops.
>
> ... Stagnation and failure to recover from disaster were primarily due to repressed inflation fiscal policies, in the cases observed, and recovery took place upon abandonment of those policies. The historical experiences also suggest conjectures, though providing only slender evidential base for them, that population is commonly "tougher" than material property in the face of physical threats, that proportionate survival of population is much more significant economically than proportionate survival of property, and that consequently recovery is possible over a very wide range of destructive attack.**

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* Ibid, p. 37.

** Ibid, p. vii-viii.

In an effort to mine the voluminous literature on reconstruction efforts following major disasters, both peacetime and wartime, Petty, Dzirkals, and Krahenbuhl prepared an extensive annotated bibliography. Major emphasis was placed on recovery from war produced, generalized disaster in highly industrialized societies, particularly since 1939. In addition to the annotated bibliography, the authors endeavored to identify major themes emerging from the disaster and recovery situations with concentration on the Soviet, German and Austrian post-World War II literature.

Petty, et al., were quite impressed with the scope and persistence of Soviet research on World War II recovery, especially since Western interest in this area had waned since the end of the 1950's. In this context, they noted:

> It appears that lessons of World War II recovery affect current Soviet planning. This can be seen in their efforts to disperse production and labor resources throughout the vast territory of the USSR, exemplified by current regional and new area economic planning that stresses horizontal integration of hinterland industrial complexes and their auxiliary resource bases. The Soviets have demonstrated a willingness to incur considerable costs in creating new communities for the relocated population that constitutes the labor force of such industrial complexes, situated away from heavily populated urban centers. Another manifestation of past lessons heeded is the comprehensive civil defense program with its stress on protection of the labor force. One should also note the extensive training in industrial trades of predraft age youths carried out under the DOSAAF program, in addition to its purely military training responsibilities.*

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*Geraldine Petty, Lilita Dzirkals, and Margaret Krahenbuhl, <u>Economic Recovery Following Disaster: A Selected, Annotated Bibliography</u>, RAND Corporation Report R-2143-ARPA, Santa Monica, California, December 1977.

Their other key observation on post-World War II Soviet recovery is with regard to the rate of industrial recovery. Together, the occupied areas had contributed 70 percent of the USSR's pre-war gross industrial output. In these areas, total population was diminished by 37 percent and the labor force reduced by 83 percent. The Soviet Union's wartime reconstruction programs concentrated on rebuilding heavy industry and transport. Despite shortages of construction crews and transport, during the war years 1942-1945, the Soviets claim to have reinstated 30 percent of all destroyed production capacity. As an example of the speed of recovery they cite the Soviet mining machinery industry, located primarily in the South. Although severely damaged by the war, the South's production of mining equipment was restored to 83.7 percent of its pre-war level by 1945.*

In summarizing German World War II recovery literature, Petty, et al., found seven major obstacles to economic recovery. These obstacles were: (1) food shortages; (2) coal and fuel shortages; (3) consumer goods shortages; (4) raw materials shortages; (5) housing scarcity; (6) transportation breakdown; and (7) fiscal imbalance--the volume of currency in circulation was huge, while only a miniscule quantity of goods was available for purchase.**

This list is useful in that it documents some key items that are essential for economic recovery following war.

Perhaps some of the most interesting thoughts regarding the different levels of economic analysis of post-war experience by the Soviets versus other European countries are contained in the following:

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* Ibid, p. 14.

** Ibid, p. 58.

> If contemporary Germans and other West Europeans have, in fact, not concerned themselves with mining their postwar experience for possible economic relevance, as the Soviets have begun doing, we must ask why. Three plausible explanations suggest themselves: To delve back into the period may have been too emotionally repugnant for the generation that experienced the war and its aftermath; to examine closely day-to-day economic realities under the occupation of nations currently their closest allies may have been politically sensitive for the Germans in particular; and to explore the postwar recovery experience may not have seemed relevant to current defense perspectives. Other explanations are no doubt equally plausible. The point here is that perhaps it is time to raise the issue of planning for economic recovery after war-related disaster; in doing so, implicit assumptions about defensive strengths and vulnerabilities may be brought to light that need to be re-examined in the context of present political and economic conditions.*

Very little effort was made by Petty, et al., to identify major themes emerging from the disaster and recovery situations. Yet they did identify several. "Recurring themes include the importance of such unpredictable events as unusually cold winters and drought; the second-order effects of hunger on economic activity; the handicaps peculiar to democratic regimes in coping with inflation; and the effects on the economic development of the receiving nations of monitoring requirements attached to outside aid."**

Sinko and Bryson's study of historical disasters differed substantially from those studies just described in two significant

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* Ibid, pp. 76-77.

** Ibid, p. 1.

ways.* First, they studied only disasters to cities, and second, they followed their study of historical disasters by constructing a simulation model to study economic recovery from disaster.

The cities studied by Sinko and Bryson included: Tokyo, Osaka, Hiroshima, and Nagasaki in Japan (World War II bombing) and San Francisco (1906 earthquake). All recovered their pre-disaster economic output within eight years (six to eight years for the Japanese cities and four years for San Francisco). The authors concluded:

> The limited data examined suggest a relationship among at least three basic factors (1) city size, (2) damage level, and (3) recovery rate. For cities above approximately 100,000 population, and destruction greater than about one-third of the industrial floor space, the time of recovery to pre-destruction industrial output is on the order of seven to nine years. This recovery time is relatively independent of the fraction of the population killed, of city size, of damage levels, and of the nature of the destruction (fire, high-explosive bombing, nuclear bombing, and earthquakes).**

Sinko and Bryson admit that their result could be interpreted as a reasonable lower bound for city recovery time in war-damaged countries because recovery occurred under favorable conditions. These conditions were that the war was over and all efforts could be directed at rebuilding. Also, the occupying authorities provided food and support.

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* James W. Sinko and L. D. Bryson, The Recovery of Cities from Major Disaster: A Conceptual Model, Stanford Research Institute, October 1970.

** Ibid, p. 3.

In their modeling effort, Sinko and Bryson developed a simulation model using the IBM 360 CSMP (Continuous Systems Modeling Program). Key model components included industrial floor space and three types of workers--essential service workers, industrial workers, and construction workers. Output was measured by gross manufactured product. Assumed were adequate outside food supplies, adequate supplies of building materials, raw materials for manufacture and capital for reconstruction. Restoration of essential services was given first priority followed by the restoration of industrial capacity. The heart of the model is the allocation among the three types of workers.

Several test cases were run, although none assuming worker fatalities. In all cases recovery of the pre-disaster state occurred in five to ten years.

Limited in scope as their model, tests and results were, Sinko and Bryson's efforts were extremely pertinent and valuable to this study. They pioneered in the use of a dynamic simulation model to study recovery from disaster. They showed that the model could be constructed and valuable insights gained in a relatively short time span and with far less resources than an input-output model would have consumed.

Two historical disasters were cited in the disaster literature where the city victimized by disaster did not recover. In these cases, virtually all of the population was destroyed. Both Hirshleifer and Sinko and Bryson discussed St. Pierre, Martinique, which was destroyed by a sudden volcanic eruption in 1902, along with nearly its entire population. In 1970, St. Pierre's population was about one quarter of its pre-1902 population. Another historical example of non-recovery from disaster was the destruction

of Khorasan by the Mongols from 1219-1221 AD. The population was destroyed or removed from the cities. The cities then remained empty for a long period of time.*

The common theme that pervades the historical disaster literature is that economic recovery following disaster takes place in a rather short time, about six to ten years. This recovery period assumes that the population of the disaster area is not destroyed.

*Described in an appendix written by Raymond Gastil to W. M. Brown's Emergency Mobilization for Post-Attack Reorganization, Hudson Institute HI-8742-RR, May 1968.

## 1.2 INDUSTRY STUDIES

Some analyses of recovery, particularly for targeting purposes, focused on specific industries and on the identification of Achilles' heels within those industries. Such points of vulnerability could lead to potential bottlenecks within those industries. With potential bottlenecks identified, preparedness measures to avoid or ameliorate the effects of those bottlenecks could be taken.

An important issue in looking at recovery of specific industries is that of substitutability. For example, labor can be substituted for some equipment by working two or three shifts on surviving equipment. Even if all of the equipment in a single plant were destroyed, other surviving plants could work extra shifts, although additional transportation would be required for materials and possibly labor.

Some substitutions of one material for another are possible and would probably be necessary during a recovery period. Some skill substitutions within labor are possible too. Under crisis conditions, new skills may be rapidly acquired.

Even in the area of energy some substitution among fuels is possible. In recent years, some industrial firms and electric power generating utilities have switched from coal to natural gas, and now some of them are switching back to coal again. Others have changed from coal to fuel oil. These changeovers do take time and resources, however.

When substitution is not possible, a bottleneck within a plant would idle most of the plant's resources until the bottleneck was removed. This causes immediate attention to the bottleneck and its removal in order to bring into production large

amounts of resources idled by the bottleneck. The elimination of the bottleneck may be obstructed, however, when the scope of the problem is beyond a single plant or industry.

Although bottlenecks have been discussed thus far in an industrial or microeconomic sense, national bottlenecks are possible too, with macroeconomic impact. Thus, a larger and more serious restriction of output can occur if an essential sector of the economy is reduced to near zero output. In such a situation, an input/output model will predict that the economy virtually halts. This stoppage is a result of the fact that in an input/output model, nearly all sectors of the economy depend on inputs from nearly all other sectors. Although, in reality, there are industries such as paint which could fall to zero output and not stop all other industries, there are others, such as transportation and energy, which if shut down long enough, could stop the economy.

These issues were apparent in a review of specific industry studies in agriculture, food distribution, aluminum, natural gas, and petroleum. Each of these industry studies is reviewed briefly here with longer reviews contained in the annotated bibliography in the second part of this report.

Brown and Pilz reported on the potential vulnerabilities of U.S. agriculture to nuclear attack.* They carried out several

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*Stephen L. Brown and Ulrich F. Pilz, U.S. Agriculture: Potential Vulnerabilities, Stanford Research Institute, January 1969.

essentially independent studies in this context. After studying the characteristics of fertilizer and pesticide application, cultivation and irrigation, farm use of petroleum and electricity, and beef cattle and poultry production, they found the implication that the most serious sources of vulnerability relate to fertilizer and petroleum. On the other hand they found that geographical imbalances between production, processing and distribution of food were not exacerbated after the attacks postulated. Two attacks were used, one counter-force and the other mixed counter-force and counter-value.

Their conclusion with regard to petroleum and post-attack agriculture is:

> Without attempting quantitative analyses, we can state immediately that without petroleum, field crop production is virtually impossible in the United States system. All major food and feed crops were mechanically planted and harvested. In addition, as has already been discussed, the application of fertilizers and pesticides and cultivation also depend on petroleum-fueled machinery...The only historical substitutes for petroleum-fueled machinery are draft animals and manpower. Neither of these possibilities is feasible in the context of national entity survival.*

Although Brown and Pilz wrote these statements ten years ago using twenty year old data in some cases, their conclusions were underscored by the fuel crisis of April-June 1979. During this period of shortage, agriculture was given priority for all fuel needed for planting.

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*ibid, page 45.

Two additional studies on agricultural vulnerability were done in 1970 by Brown and Kruzic.* One study tested several assumptions for their impact on damage assessment, while the other looked at trends in the use and manufacture of fertilizer. The authors suggested that agricultural vulnerability may be a moot topic, however, since much greater efficiencies could be achieved by attacking the petroleum refining capacity with resulting damage nearly as harmful to agriculture, and, in addition, crippling other sectors of the economy.

Billheimer, Jones and Myers** studied alternatives for distribution of food to evacuated populations under crisis relocation conditions. Using Colorado Springs as a case study, they found the most effective distribution strategy under crisis relocation conditions is to allow agricultural output to follow normal distribution channels through major processing plants to wholesale warehouses which are then used as retail outlets and mass feeding stations. Problems they noted included hoarding and transportation system stress.

A serious problem not addressed is how people are going to get to these wholesale warehouses when transportation will be severely disrupted. Often the wholesale food warehouses are large

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*Stephen L. Brown and Pamela G. Kruzic, Agricultural Vulnerability in the National Entity Survival Context, Stanford Research Institute, July 1970.

**John W. Billheimer, Frank J. Jones, and Myron Myers, Food System Support of the Relocation Strategy, Part I: Analysis and Case Study; Part II: Prototype Plans; Part III: Planning Guidelines, Systan, Inc., September 1975.

facilities located at greater than walking distance for much of the population of large urban areas.

Even though their study looked at food distribution under crisis relocation conditions, it has strong implications for post-attack food distribution. If hoarding and transportation system stress are problems for food distribution under crisis relocation conditions, these problems will be strongly amplified under post-attack conditions.

Block et al.* studied the aluminum industry and found it to be easily interrupted by a nuclear attack, but hard to destroy unless directly targeted. Among their discoveries is that solidified pots of aluminum are not ruined and can be restarted following a power outage. That electric power may not be available continuously, or in large quantities following a nuclear attack was not considered.

Stephens** studied the total petroleum industry including production, refining, transportation and marketing. He focused on the impact of a nuclear attack on the petroleum system within the State of Louisiana. He concluded that this industry is extremely vulnerable due in part to the delicate nature of computer controlled refineries, the industry's concentration,

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*E. B. Block et al, Initial National Survivability Study, Summary Volume, Stanford Research Institute, Technical Note SRD-EG34, October 1977.

**Maynard M. Stephens, Vulnerability of Total Petroleum Systems, Department of the Interior, Office of Oil and Gas, Prepared for Army Office of Civil Defense, 1973.

and vulnerability of its pipelines and water transportation system. Although this report contains data on the output of the petroleum system, it does not speculate on how reduction of that output would impact the rest of the economy.

Stephens and Golasinski* described the U.S. natural gas industry in detail and cited its vulnerability to disruption by sabotage or by nuclear attack. The pipelines and compressor stations are noted to have little or no security. Also major pipelines have no standby equipment or alternate routes. Domestic supplies of natural gas are largely drawn from Louisiana and Texas.

The concentration of supplies and the lack of backup equipment make the industry extremely vulnerable to nuclear attack. The authors recommend a contingency plan to devise methods to use substitute fuels for natural gas in places where storage of natural gas would cause serious problems.

Large gas processing plants, to remove impurities and sort out other salable gases and gas liquids are analogous to oil refineries and are just as vulnerable to nuclear attack. They conclude: "The vulnerability of the field gas system...is essentially the same as the vulnerability of the crude oil system" discussed in Stephen's report cited above.

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*Maynard M. Stephens and Joseph A. Golasinski, Vulnerability of Natural Gas Systems, Department of the Interior, Office of Oil and Gas, Prepared for Defense Civil Preparedness Agency, 1974.

The industry studies reviewed here all directly or indirectly pointed to energy and/or transportation as significant post-attack problems, with energy perhaps the key to transportation. Industrial equipment can be protected* but even if workers, equipment and materials survive, industrial production requires energy. Also, transportation is required to receive inputs for production and to deliver the outputs.

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*See, for example, T. K. Jones, Industrial Survival and Recovery After Nuclear Attack, Boeing Aerospace Co., Report D180-20236-1, 1976.

## 1.3 ECONOMIC RECOVERY MODELS

The great majority of economic recovery analyses that have been reviewed are based on input/output models. The reason that so many studies using input/output models have been reviewed is a direct result of the fact that nearly all quantitative analyses of economic recovery written since the early 1960's are based on such models. A few of the studies reviewed use linear programming models to optimize an objective function, but even these models frequently use input/output submodels to keep track of interindustry flow. In a few studies, econometric models are used in an attempt to model the dynamic aspects of recovery. Some other modeling approaches have been suggested in the studies reviewed, but none have been carried much further than the conceptual stage except for the recently started efforts using system dynamics.

Input/output models depict the economy as a set of interdependent sectors, the output to some sectors being required as the inputs of others in their productive processes. Input/output analyses assume that the ratio of one sector's inputs to its outputs is fixed. Thus, to double the ouput of steel, for example, the input of coal to the steel sector has to be doubled.

Input/output models assume that there is no substitutability between sectors. In addition, they implicitly assume that there is infinite substitutability within a sector. Such assumptions are reasonable when dealing with small changes in the present (peacetime) economy. However, for the major dislocations and shortages that would result in the post-attack period, these assumptions make input/output analysis questionable as a methodology for analyzing all but the final stages of post-attack recovery.

In addition to the problem introduced by substitutability being inherently built into the model rather than an exogenous input to the analysis, there are a number of other objections to the use of input/output analysis for analyzing the post-attack period. There are no lag times in the analysis, since the supply of necessary outputs from other sectors is always assumed to be available. Input/output analysis cannot take into account the depletion of inventories or the building of capital for investment. And, post-attack resource allocation decisions, dynamic as they are, cannot be included. In short, the steady-state analysis afforded by input/output models will not take into account the many factors that must come together for recovery. Attempts have been made to make input/output models quasidynamic by changing coefficients exogenously, but as yet no truly dynamic input/output models have been built.

The number of coefficients required for an input/output analysis with several hundred sectors runs into the hundreds of thousands and the number of multiplications runs into the millions. Attempts to modify input/output analyses to make them more applicable to post-attack recovery multiplies these calculations manyfold. As a result, even if input/output models were suitable for analyzing post-attack recovery, they do not appear to be likely candidates for optimizing attacks or for answering "what if" questions.

A few studies of the post-attack period have used linear programming models.* Instead of looking for a deterministic

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*See, for example, F. W. Dresch and S. Baum, Analysis of the U.S. and U.S.S.R. Potential for Economic Recovery Following Nuclear Attack, Stanford Research Institute, SSC-TN-8974-85, January 1973.

solution to a set of equations, the equations represent constraints rather than absolute conditions, and outputs are chosen to maximize or minimize some objective function. In this way, a linear programming model can be designed to allow for the depletion of inventories and for the under-utilitization of capacity. Thus, it can remove some of the objections to input/output models.

The main advantage of a linear programming model is that it can be used to optimize and, therefore, to test the influence of different feasible solutions on the objective function. This flexibility does not come without its price tag. The number of calculations required to solve a linear programming problem of the same complexity as an input/output analysis is much greater. Nevertheless, techniques have been developed for solving linear programming problems of substantial size, and a few attempts have been made to use linear programming, usually in combination with input/output analysis, for analysis.*

A more recent development is the use of macroeconometric models to describe the economy. In macroeconometric models, a number of equations are established to represent the value of a variable at any point in time, based upon the value of that variable at a previous point in time and the values of other variables. Since an econometric model is designed to predict the changes in values of the variables over time, it can take into account lag times, and by its inherent design, it is dynamic. The fundamental relationships to depict the dependence of each variable

*See, e.g., R. Laurino et al. Impacts of Crisis Relocation on U.S. Economic and Industrial Activity, Center for Planning and Research, Inc., 1978.

on other variables are determined, in part, from statistical studies of the correlation of these variables when viewing the past history of the economy, and in part, from the modeler's understanding of the way the economy behaves.

The major problem with a macroeconometric model is that the modeler must have relevant data of past behavior in sufficient quantity and detail to draw statistical inferences from that data. In analyzing post-attack recovery, such data are rather hard to acquire. Another objection is that this approach does not distinguish between cause and effect. This makes it difficult to test alternative policies, since without any relevant data, we cannot know whether the coeffecients will remain unchanged when significant changes in one of the variables are brought about through policy changes.

A review of the different types of economic models that are available and the problems associated with each is given by Neu.* Neu comments that it would be fruitless to build a purely economic model or recovery as such since it is exactly those aspects of the economic system which have proven most difficult for economists to treat adequately--organizational structures, transportation, information flows, and resource allocation mechanisms--which are likely to be most seriously disrupted and, thus, of the greatest importance in the process of recovery.

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*C. R. Neu, Economic Models and Strategic Targeting (U), The Rand Corporation, R-1846-ARPA, June 1976, Secret.

Neu sees little hope of predicting actual post-attack investment behavior. He therefore suggests that one approach would be to credit an economy with decisions which are in some sense optimal, thereby providing an upperbound on the rate of recovery. Another approach suggested by Neu is to deal with the whole range of possible states which the recovering economy could reach in a given length of time. This range is known as the feasible set for an economy at any given time. Although such an analysis would be massively large and complex, a number of small models might be used to give a broad outline of the boundary of the feasible set.

Since a tremendous amount of effort has already been spent on economic modeling of post-attack recovery and yet we know very little about the problems that might endanger the prospects for recovery, it appears worthwhile to step back and ask ourselves: what is the purpose of modeling of economic recovery? Basically, we are trying to obtain a meaningful measure of the results of a large-scale attack which will be useful either for designing effective civil preparedness measures or for targeting in a way that will maximize the impact on post-attack recovery.

In a steady state economy, investments at the margin are expected to yield the same return. (In a free market economy, this is roughly equivalent to saying that each dollar invested properly, no matter where it is invested, contributes the same amount to the economy.) Consequently, for destruction levels which are small enough not to alter the fundamental economic way of life of the nation, we could make a fairly accurate comparison of post-attack capabilities simply by comparing the remaining capital and human assets. In other words, a damage assessment model would be adequate for comparing post-attack capabilities in cases where the destruction is small.

For larger attacks, this simple relationship between investment and capability no longer can be expected to hold. For example, investment in a plutonium reprocessing plant is not likely to be anywhere near as valuable to a recovering economy as the same investment in oil refineries or electrical generating plants. In order to take into account these kinds of differences, a model of the post-attack economy should take into account the marginal effect on demand of different investments in the post-attack economy. In other words, the demand structure of the economy will be altered significantly by the attack, and, as a consequence, the relative value of different investments will be different from that of the pre-attack economy.

This presents a dilemma. The input/output models and econometric models that normally are used to analyze post-attack recovery are necessarily based upon assumptions about the pre-attack relationships between different parts of the economy. As stated above, if these relationships are relatively unchanged, we can get an adequate estimate of post-attack capability simply by examining the results of a damage assessment model. In that case, we do not need the more detailed macroeconomic models. Those cases where we do need more than a simple damage assessment model are exactly those cases in which the vast majority of the present models do not apply, namely those in which there is a significant change in demand.

It is concluded that, in spite of the large number of models that have been developed for the analysis of economic recovery, adequate models do not yet exist. It is also concluded that it does not appear that further refinement of existing models will significantly improve their usefulness. Different approaches appear to be needed. Neu's proposal of using a number

of small models to gain insight into different aspects of recovery appears to be promising. Also his observation that it would be fruitless to build a purely economic model of recovery appears to be very well taken. For a model to have any hope of giving roughly right answers about post-attack recovery, it must treat organizational structures, transportation, information flows, and resource allocation mechanisms.

The greatest promise for a model to incorporate some of the aspects just mentioned lies in the area of system dynamics. This modeling method and its potential for economic recovery modeling with linkage to civil preparedness is discussed at length in section 1.11 of this report.

## 1.4 VIABILITY STUDIES

It has long been recognized that the basic threat to a nation is a threat to its economic viability. An economy is viable if it is functioning and capable of producing, without external aid, an output sufficiently large and appropriate in composition to: (a) provide its workers and its families with a level of consumption high enough to maintain their productivity and to give them the incentive to continue to contribute their services to the economy in a socially productive way; (b) meet any fixed claims* on its output that may exist; and (c) maintain the stock of real capital (including inventories) required to accomplish (a) and (b).

The reasoning behind this definition of viability is that viability is achieved only when a nation is meeting its essential economic needs from output. It can be expected that there will be a substantial period of time after an attack when the nation meets a significant portion of its essential economic needs out of inventory. *The struggle for viability is a race between re-establishing output adequate to meet the essential needs of the economy and the exhaustion of existing inventories.* Unless production of the necessities of life can be resumed, whatever success there has been in protecting the population from the immediate consequences of the war will dissipate as supplies of food, medicines, and heating oil disappear; the surviving thermal generating plants exhaust their supplies of coal and fuel oil; and starvation, disease, and exposure take their toll.

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*"Fixed claims" refer to claims that, as a matter of national policy, would be met even if the results were a failure to accomplish (a) above; for example, (1) burdens of national security, and (2) support for non-productive elements of the population.

It is at this stage that the most formidable organizational problems will present themselves. Even if the plant and equipment, the skills of the labor force, and the transportation and communications systems are fully adequate for winning the race between the recovery of output and the depletion of inventories, a failure to achieve viability could easily occur if these resources are not effectively marshalled. The plans, the authority, the effective organization, and the general overview of the situation may not exist, particularly, as is likely, if the nation's capitol and some state capitols are destroyed in a war. The market economy is likely to be paralyzed by immense uncertainties as to property rights, the breakdown of the monetary system, the destruction of organized exchanges, and the shortages of communications. Even a planned economy is susceptible to the paralyzing effects of these uncertainties.

The reorganizing economy faces critical deadlines. If inventories of items essential to the support of the population or to the reconstruction effort are exhausted before production is adequately restored, the reorganization will fail. The health and vigor of the population and the willingness and ability of the labor force to continue to engage in productive efforts will be adversely affected as supplies of the necessities of life fall to or below minimum requirements. Output will then decline, both as a result of the weakened condition of the labor force and of the inevitable rise in absenteeism as individuals attempt to meet their own and their family's needs by foraging, plundering, or selling their household goods. Ultimately, there will be a complete cessation of organized national effort towards long-term reconstruction. Immediate threats of starvation, disease, and exposure will soon reappear. But there will be no inventories from which

to meet these threats, no period of grace while a permanent solution is found. The result will be a catastrophe, perhaps of the same order of magnitude as the war itself.

It is usual to jump quickly from the previously given, general definition of viability to the definition of the technological capability for viability. When dealing with the technological capability, one ignores the management and information flow necessary for output to equal capability, and one ignores the differences between minimum essential consumption needs and consumption which is adequate to maintain productivity and to motivate workers. By concentrating on technological capabilities only, the analyst is able to avoid analyzing, or at least trying to analyze, the formidable organizational problems that exist, the impact of the health and vigor of the population on productivity, the motivation of the population to be productive, etc. Thus, the analyst's job is greatly simplified, but the relevance of these results is questionable.

The seminal work on technological aspects of viability was written by Sidney Winter in 1963.* A number of different ranges of attack size are considered in this study; it is concluded that for a total attack weight of 1,000 to 4,000 megatons, 750 to 2,000 of which are on non-military targets, the loss of industrial capacity would create serious to insuperable obstacles to viability unless extensive pre-attack preparations were made.

Other studies included in this review which investigated economic viability looked at a small number of specific attacks

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*S. G. Winter, Jr., Economic Viability After Thermonuclear War: The Limits of Feasible Production, The Rand Corp., RM-3436-PR, September 1963.

only, none of which were designed to destroy viability. These other studies concluded that the capability for viability would be present after such attacks. Winter himself, in a later paper, states that:*

> If one focuses on physiological subsistence requirements, postulates a very effective rationing system, and assumes that the physical destruction resulting from the attack is the main source of production losses, then it is easy to convince oneself that a situation in which economic viability would be threatened is quite implausible.

However, many of these studies are caveated with statements similar to the one by Bernard Sobin which stated that no way exists for measuring the extent to which resource management problems will degrade the performance of the economy.** Thus, although these studies conclude that the techlogical capability will be present, they are not so sanguine about the prospects for viability actually occurring, given the tremendous management problems that must be solved.

Another form of viability is local viability. This form was addressed by Dresch and Ellis*** who considered seven areas: physical, economic, transportation and communications, utilities, government, survivors and medical. They conclude that the criteria for local viability reduce to avoiding:

1. denial to some or all of an SMSA because of radiation or other hazardous conditions;

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*S. G. Winter, Jr., The Federal Role in Post-Attack Economic Organization, The Rand Corp., P3737, November 1967.

**B. Sobin, Post-Attack Recovery, Research Analysis Corp., RAC-P-51, June 1970.

***F. W. Dresch and H. B. Ellis, Criteria for Early Post-Attack Viability of Local Areas, Stanford Research Institute, June 1974.

2. lack of housing as a limit of the population and labor force; and

3. local transportation blockages that interrupt the flow of essential supplies to survivors of local industry.

Even if these criteria are accepted as sufficient, measuring local viability with regard to these recommended criteria is far from a simple task.

It is concluded that the issue of viability remains an open issue which is not satisfactorily addressed by previous studies. It appears to this reviewer that the issue of viability is the most crucial issue that should be resolved in future studies. This issue cannot be addressed by looking at the technological factors only; considerations of management of the economy during the various "phases" of post-attack survival and recovery should receive particular emphasis.

## 1.5 SURVIVAL PHASE

The phase immediately following an attack is called the survival phase. During this phase, the principal task facing the nation will be to assure that the survival of these efforts will depend almost entirely on preparations made before the attack. Preparations made include stockpiling of medical supplies, food, and other survival items; the development of large, adequately trained and effectively organized civil defense workers; and the preparation of adequate shelter space. New production will play a minimal role in support of the activities being conducted. Even if a sufficient amount of new production were possible during this time, the urgency of the requirements would be such that not enough could be produced in time to make a significant difference to population survival.

Needs will have to be met out of surviving inventories, principally from the resources of areas that escaped damage or are damaged only slightly. The major problems will be developing the transportation, communications, and organizational capabilities required to bring these resources to bear at the points where they are needed. In view of the overriding importance of meeting immediate threats to millions of people, it is unlikely that much effort will be made to conserve resources for meeting possible future requirements. Together with little or no new production, this implies that inventories of some items are likely to decline rapidly.

A number of studies that are reviewed in this report look at the survival phase. The magnitude of the initial post-attack

recovery estimates is discussed by Goen.* This report estimates the magnitude of life support tasks from the time the survivors emerge from the shelters until they have been provided with adequate housing. It looks at tasks such as debris clearance, delivery of food and water, decontamination, relocation of the homeless survivors, and boarding broken windows. Estimates are made of the effort, equipment and number of men required for these tasks.

The information requirements for managing recovery activities are investigated by Dresch.** This study is applicable to both the survival phase and the reorganization phase.

An interindustry model of the U.S. economy in the first 90 days after a nuclear attack is developed by Bull.*** Since it is doubtful that current production will play an important role in the survival phase, the utility of this model for analysis of the survival phase is questionable.

Many other studies touch on the activities during the survival phase, but it is nearly impossible to present a comprehensive

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*R. L. Goen, The Magnitude of Initial Post-Attack Recovery Activities, Stanford Research Institute, December 1971.

**F. W. Dresch, Information Needs for Post-Attack Recovery Management, Stanford Research Institute, April 1968.

***E. M. Bull, The Runout Production Evaluation (ROPE) Model: Structure and Methodology, American Technical Assistance Corporation, June 1973.

picture of this phase. At best, one can gain insight from examining specific scenarios. A provocative scenario covering the events leading up to a nuclear exchange between the U.S. and the Soviet Union is developed by Gastil.* This scenario provides insights into potential problems, especially problems that might be alleviated by pre-attack plans and preparations. This scenario gives the impression that recovery is very likely to be a local, not a national endeavor. Consequently, any realistic model of the survival phase should take local differences into account.

Other than the interindustry model proposed by Bull, the only model dealing with the survival phase that is reviewed in this report is the one proposed by Sinko and Bryson.** This model looks at one significant aspect of the survival phase--the allocation of workers between the essential services, construction, and industrial production. The model assumes a function for the distribution of time that it takes before workers are released back into the production sector. Although this model is only illustrative of the approach, it is the only model that has been reviewed which shows promise of providing a start into the analysis of allocation tradeoffs during the survival and reorganization phases. The recently begun efforts involving system dynamics models are anticipated to shed considerable light on these tradeoffs.

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*R. D. Gastil, Scenario for Post-Attack Social Reorganization, The Hudson Institute, HI-1188-RR, August 1969.

**J. W. Sinko and L. D. Bryson, The Recovery of Cities from Major Disasters: A Conceptual Model, Stanford Research Institute, October 1970.

The primary problems during the survival phase appear to be associated with information, communication, and transportation. If the surviving government knows the needs of the surviving population, knows the status of the human and material resources that are needed to meet these needs, and has the necessary communication and transportation available for informing the survivors of its decisions and marrying the surviving resources with the needs, it is likely that the survival phase will be successfully navigated, at least for the attacks that are considered in the studies which are reviewed in this report.

## 1.6 PHYSICAL VULNERABILITY/DAMAGE ASSESSMENT

A number of reports were reviewed that are pertinent to the issue of physical vulnerability/damage assessment. Some of those reports were the ones reviewed in section 1.2 as industry studies while others considered a national view. After a few brief remarks on the single industry studies, those of national scope are reviewed vis-a-vis vulnerability and damage assessment.

Industry studies reviewed that considered vulnerability included areas of agriculture, aluminum, petroleum and natural gas. A common point of concern relating to these studies is energy. Brown and Pilz found that fertilizers and farm equipmetn were crucial to agriculture and were vulnerable to a loss of petroleum supplies.[*] Stephens found that total petroleum industry to be extremely vulnerable to nuclear attack[**] due to its concentration, delicate control equipment and exposure of its transportation system. Stephens and Golasinski found similar vulnerability in the natural gas system.[***]

Block et al. concluded that the aluminum industry would be interruptible but hard to destroy unless directly targeted.[****] They did not consider the vulnerability of aluminum industry output to loss of electric power supply, perhaps because it is so obvious that they felt it did not need mentioning.

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[*] Stephen L. Brown and Ulrich F. Pilz, op. cit.

[**] Maynard M. Stephens, op. cit.

[***] Maynard M. Stephens and Joseph A. Golasinski, op. cit.

[****] E. B. Block, et al, op. cit.

Brown and Kruzic performed a study of U.S. agricultural vulnerability with regard to several assumptions.* Various assumptions included: weight of attack, duration of assumed vulnerability, type of attack, and efficiency of attack. The most sensitive assumption turned out to be efficiency of attack, i.e., whether or not the attack is directed toward maximum damage to agriculture. This finding may well be applicable to the vulnerability of other industries.

One of the most prominent studies of national scope pertinent to vulnerability and damage assessment was PONAST II.** The PONAST II study was prepared by an interagency study group in response to a request by the Joint Chiefs of Staff. The study was under the overall direction of a steering group, consisting of member from the Office of the Assistant Secretary of Defense (Systems Analysis), Defense Intelligence Agency, Defense Communications Agency, Defense Civil Preparedness Agency, Office of Emergency Preparedness, State Department, Central Intelligence Agency, and chaired by a representative of the Joint Chiefs of Staff.

PONAST II is a study of the survival and recovery prospects of the United States and the Soviet Union, following a hypothetical massive nuclear attack on the United States by the Soviet Union, which, in turn, is quickly followed by a U.S. counter-attack on the U.S.S.R. One of the principal purposes of the study was to provide insights useful for U.S. nuclear contingency planning. Although this report is oriented toward

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*Stephen L. Brown and Pamela G. Kruzic, op. cit.

**J. Pettee, et al., PONAST II, Office of Civil Preparedness, 1972.

U.S. civil defense and recovery, it should be noted that current Soviet civil defense plans, which consist basically of evacuating their larger cities, were found to be highly effective in limiting the number of Soviet casualties.

PONAST consisted of a computer simulation of the nuclear exchange. The assumed magnitude of the attack and counter-attack was what might reasonably have been expected if a war had actually occurred in early 1971. It was assumed that the U.S. evacuated 10 percent of their cities with populations over 100,000 and that the Soviets evacuated 70 percent of the people in similar size cities. The attack of the United States consisted of 1,400 warheads, containing 6,800 megatons. The Soviets applied about one-third of their megatonage to urban/industrial targets in the U.S., the remainder being applied to U.S. military targets. There were 94 million fatalities in the United States. Of the 109 million survivors, 35 million were injured. About three-quarters of the fatalities and three-fifths of the nonfatal injuries were caused by weapons effects. The remainder were caused by fallout.

A number of excursions were carried out to investigate alternative civil defense measures in the United States, and the cost and effectiveness in terms of surviving population are compared for these alternatives. Both evacuation and shelter are considered. One evacuation program increased the percent surviving from 54 percent to 93 percent, while increasing the cost per survivor from the base case of about $10 to about $50. This posture assumes 100 percent evacuation of the metropolitan areas with everyone in fallout shelters with a protection factor of 40 or better. The results of the study showed that the reconstitution of the national government was possible. The criterion used for national survival was the viability of the major metropolitan areas.

Pettee also was involved in the UNCLEX-73 exercise* which assessed the damage of two different 1,200 weapon, 600 megaton attacks. Industries cut deeply by these attacks were drugs, petroleum refining, equipment production for electronics and electric power distribution, and major military equipment production. The threats that such industry output shortages pose to national survival are suggested but deemed conjectural or scenario dependent. There is an interesting aspect of vulnerability raised in Volume II of this study, namely, institutional vulnerability. The report summarizes that:

> the most serious threat to national survival reflected in these two case studies probably lies in the tremendous institutional improvisation and reconstitution requirement which must be met by a severely reduced government structure.

In other words, institutional vulnerability may be a greater threat to national survival than physical vulnerability.

In some ways an update of PONAST II, Sullivan, Heller and Aldridge** analyzed candidate U.S. civil defense programs under a mid-1980's Soviet attack against both counterforce and countervalue targets. Two attack scenarios included counterforce and countervalue targeting, with the first having targeting of residential population and the second targeting of relocated population. Six specific civil defense programs were used along with two options to these programs. The six civil defense programs were:

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*James C. Pettee, Unclassified Nuclear Case-Lesson Example of 1973 (UNCLEX-73), Volume I, Scenario and Attacks for UNCLEX-73, June 1973, and Volume II, National Survival after UNCLEX-73, November 1978, Federal Preparedness Agency (both volumes).

**Roger J. Sullivan, Winder M. Heller, and E. C. Aldridge, Jr., Candidate U.S. Civil Defense Programs, System Planning Corporation, Report 342, 1978.

A. No civil defense

B. Current civil defense program

C. Best use of existing shelters by in-place population

D. Relocation of risk area population to rural areas with some fallout protection

E. Risk area population relocated to a lesser extent but provided 15-psi blast protection

F. Extensive blast shelter program with protection of 100-psi and PF500.

Casualties ranged from 80 percent of the population for Program A to 60 percent for C to 20 percent for E (without retargeting relocated population) to 10 percent for Program F. Estimated program costs in 1979 dollars ranged from $50 million for Plan A to $80 billion for Plan F.

Goen, Bothun, and Walker* assessed the damage of an 800 weapon, 500 megaton attack on the U.S. Damage was assessed to manufacturing, petroleum pipelines, electric power production and housing. The authors concluded that:

> Significant compensation for losses in generation and transmission capacity losses can be accomplished by effective post-attack management in power consumption.

By this is meant rationing, elimination of non-essential users and staggering peak demand hours. They also reaffirm the vulnerability of the petroleum distribution system but state that rail and truck transportation could be substituted for pipelines.

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*Richard L. Goen, Richard B. Bothun and Frank E. Walker, Potential Vulnerabilities Affecting National Survival, Stanford Research Institute, September 1970.

Using Goen, Bothun and Walker's postulated attacks, Katz* reviews national effects and examines in greater detail the effects of such attacks on Massachusetts. His attack damage estimates are higher than those of PONAST II. This is due to Katz's assumptions that do not appear to include crisis buildup or relocation. He points out that agricultural output will drop significantly due to the loss of petroleum products including both fuel and fertilizer since 98 percent of refining capacity is predicted to be lost. Also, severe loss of medical personnel and treatment facilities is predicted due to their concentration in large cities.

In reviewing these sutdies of vulnerability and damage assessment, several observations emerge. First, civil defense assumptions strongly affect damage and vulnerability estimates. Second, the petroleum system is extremely vulnerable and the nation's agriculture and industries are vulnerable to a cutoff of petroleum. Measures which provide for the survival of a significant portion of the petroleum system is a civil defense option that appears to be worth high priority.

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*Arthur Katz, Economic and Social Consequences of Nuclear Attacks on the United States, a study prepared for the Joint Committee on Defense Production, U.S. Congress, 1979.

## 1.7 U.S. CIVIL DEFENSE

The current U.S. civil defense program has stressed development of plans and capabilities to protect the population in place, that is, at or near their homes and places of work, although planning for the contingency of crisis relocation started in most states in FY 1977. At the current funding levels, these relocation plans would not be completed until the late 1980's, and the current program does not provide for exercising key local and state officials in the actions which they would need to take to execute the plans effectively should the need arise.

Support for civil defense in the United States has not displayed the consistency that is evident in the Soviet civil defense program (see Section 1.8). Civil defense appropriations have varied considerably since the time that the civil defense program was begun in FY 1951. A large surge in civil defense appropriations occurred as the result of the Berlin crisis, but interest in civil defense quickly declined after the Cuban missile crisis, and appropriations declined accordingly. The history of civil defense appropriations in the United States is shown in Figure 1-1.*

The civil defense program in the United States officially began with the enactment of the Federal Civil Defense Act of 1950. This act was passed as a result of the concerns which arose from the detonation in 1949 of the first Soviet nuclear device and the Korean War. Lack of suitable protection against fire and blast

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*See Ralph L. Garrett, Civil Defense and the Public: An Overview of Public Attitude Studies, Research Report No. 17, Federal Emergency Management Agency, September 1979.

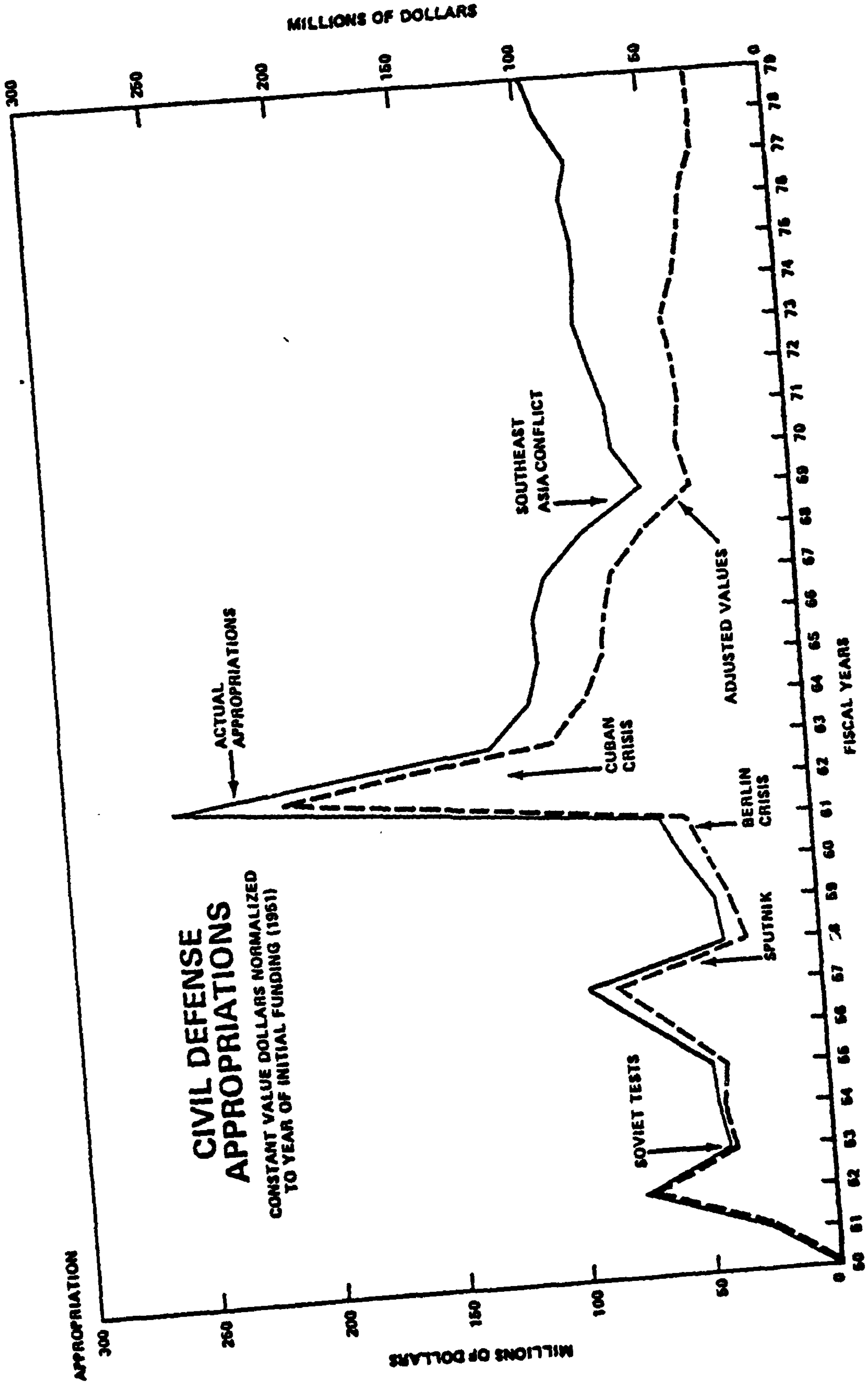
CIVIL DEFENSE APPROPRIATIONS
CONSTANT VALUE DOLLARS NORMALIZED TO YEAR OF INITIAL FUNDING (1951)
APPROPRIATION
MILLIONS OF DOLLARS
MILLIONS OF DOLLARS
FISCAL YEARS
ACTUAL APPROPRIATIONS
ADJUSTED VALUES
SOVIET TESTS
SPUTNIK
BERLIN CRISIS
CUBAN CRISIS
SOUTHEAST ASIA CONFLICT

Figure 1-1

effects led to plans for rapid evacuation of cities during the several hours anticipated between warning that an attack had been launched and the arrival of enemy bombers. The advent of thermonuclear weapons, with a nationwide threat of fallout, and the prospect of rapid delivery of these weapons by ICBM's led to a major change in concept. By 1956, there was a consensus that the civil defense posture should be based on blast-resistant shelters in major cities and fallout protection elsewhere.

As a result of the Berlin crisis, the President decided in 1961 to initiate a program to provide fallout shelters for the entire population. The national shelter survey program was initiated on a crash basis. The steps in this program includes: (1) survey, mark and stock shelters in existing structures; (2) subsidize the incorporation of fallout shelters in new construction and shelter efficient areas; and (3) build single-purpose fallout shelters if and where needed. Only the first step in this program was authorized, perhaps as a result of the evolving of strategic thinking in the United States to a point where deterrence was to be based on "Assured Destruction," a policy which required that the citizens of the United States be kept hostage to a Soviet attack.

The civil defense program was broadened starting in the early 1970's to include peacetime as well as wartime hazards, resulting in increased emphasis on dual use plans, procedures, and preparedness. The 1970's also brought a new stress on operational capabilities of all assets available to a community, from warning systems to shelters and radiological detection instruments and personnel, police and fire fighting forces, to doctors and hospitals, to the talents of its key executive officials. The development of these operational capabilities came under the program called On-Site Assistance.

In the mid-1970's, the last major element of the full spectrum preparedness program was initiated--contingency planning to relocate populations for U.S. metropolitan areas and other risk areas during a period of severe international crisis.

The current civil defense program includes paid staffs of approximately 5,500 manyears per year, of which about 88 percent is in state and local civil defense agencies. Nearly all of the DoD budget for civil defense has been spent on personnel costs.

Outlined below are the highlights and current status of major elements of the U.S. civil defense program.

1. Nuclear civil protection

   a. Crisis relocation planning: Includes planning for relocating the population of U.S. metropolitan and other risk areas during a period of intense crisis, including provision for the logistics support and evacuees in host areas, for development as necessary of fallout protection in host areas, and for keeping essential risk area services and industries in operation through commuting by key workers from nearby host areas. Crisis relocation planning is now in a transition status from the research test and development phase.

   b. Community shelter planning: Includes planning for the use of best available nearby shelters in homes or large buildings for in-place protection when time or circumstances preclude crisis relocation. Community shelter planning provides the basis for local emergency operations plans, based on use of all locally available forces to assist the population to move to shelter, and to support them in shelter. Community shelter planning has been accomplished for areas containing about 160 million people, but some of these plans are in need of updating.

c. Shelter surveys and marking: Surveys identified best available existing fallout protection in host areas, and fallout and blast protection in risk areas. The host area survey also identified buildings whose fallout protection can be improved in crisis actions. Through FY 1971, about 118,000 buildings had been marked with the yellow-and-black shelter signs; approximately 95,000 buildings not now marked are planned for use, but no Federally-supported shelter marking is contemplated. Shelter marking is to be a crisis-period action.

d. Shelter stocks: In the earlier 1960's, the shelter program included Federal purchase of austere survival supplies for shelters (food, water containers, and medical, sanitation, and radiological-monitoring kits). The shelf life of these supplies has expired, and they either have or will be removed from shelters. Shelter stocking is to be accomplished by crisis-period action, and stocks will be required for approximately 125 million of the surveyed spaces.

2. Direction and control

a. Federal communications: Includes voice and teletype circuits linking the National Headquarters (including relocation sites), the eight regions, selected Federal agencies with emergency responsibilities, and the States. The land-line systems are backed up by high-frequency radio links to 49 states. Neither the land-line nor radio systems provide secure voice communications which would be required for operation in crisis and attack periods.

b. Regions: six of the eight regional offices are situated in underground centers with substantial protection

against nuclear weapons effects and facilities for emergency operations. Underground centers are required for the remaining two regions.

c. States: 43 of the states have state-level emergency operating centers.

d. Local: Emergency operating centers with good protection against fallout are operational or under development in localities including about half the population.

3. Attack warning

a. National Warning System: The National Warning System is a nationwide attack warning dedicated land-line system over which warnings can be disseminated nearly instantaneously to over 1,200 Federal, State, and local warning points which operate on a 24-hour basis. Although this system permits nearly instantaneous dissemination of warning to all points on the system, the further dissemination of the information to other locations and the public, in many places, is inadequate due to inefficiency of systems at the local level.

b. Local warning system: Once attack warning has reached a warning point at local levels, it is usually disseminated to the public by outdoor warning devices, primarily sirens. Forty-seven percent of the U.S. population is in areas that could receive outdoor warning within 15 minutes or less from the time warning was initiated at the national warning center.

4. Radiological defense: Includes radiological detection instruments, communications, plans and procedures, and trained personnel required to detect and evaluate radiological hazards,

as a basis for advising citizens on protective action and decisions on use of operational resources. Some 2.4 million radiological monitors are required but not available. It is planned that they will be trained as a crisis period action.

5. Emergency public information

a. Emergency broadcast system: Fallout protection, emergency power generators, and remote programming units have been provided for radio stations in the Emergency Broadcast System, to permit broadcasting emergency information to the public under fallout conditions. Approximately one-third of the stations are in high-risk areas and could be made inoperative by blast. A program has been initiated to provide electromagnetic pulse (EMP) protection for 180 stations.

b. Local plans and procedures: About one-third of the more than 5,000 localities participating in the civil defense program have reported that they had developed plans and procedures to provide advice and information to the public in emergency period.

6. Citizen training: The civil defense program formally provided substantial training for the public at large, but crisis training via news media must now be relied on to educate citizens as to attack hazards and survival actions.

The effectiveness of this program has been described by C. E. McLain, while Deputy Director of the Defense Civil Preparedness Agency, as follows:

> The current situation of civil defense in the U.S. is that a system exists which partially provides a basis for effective expedient "surge mode" actions if sufficient time and resolve were provided between strategic warning and attack. In a one to two-week period of action and national resolve from warning to attack, the current program provides for: saving about ten

> million lives, a minimal probability of survival for the Federal Government teams deployed in the protective arc around the National Capitol, a reasonable probability of survival for the President, and essentially no protection of industry or the economic base. Certain of the currently existent crisis relocation plans are probably subject to retargeting. The current relocation facilities for preserving the continuity of the Federal Government are very vulnerable to deliberate Soviet attack against the Federal Government. No highly survivable $C^3$ and resource inventory and allocation system currently exists by which recovery could be managed from a national center immediately following an attack.*

In 1977-78, the Defense Civil Preparedness Agency sponsored an evaluation of alternative civil defense postures.** Five specific civil defense postures were chosen for detailed analysis. Posture 1 represents the case of "no civil defense" and was included primarily to provide a reference point for the effectiveness of other postures. In Posture 2, the population is assumed to remain in place but to make best use of presently available shelters as specified by the National Shelter Survey conducted by DCPA; these shelters are taken as being ready for occupancy by the time the attack occurs. Posture 3 is one where the population is relocated to farms and hamlets, and is provided some fallout protection. Posture 4 corresponds to a less extensive relocation along with some blast shelters (15 psi) in the host areas. Posture 5 represents extensive in-place protection: 100 psi blast shelters in all populated areas.

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*C. E. McLain, Objectives for Preparedness and Their Implications for Civil Defense Design Options. (Washington, D.C.: Defense Civil Preparedness Agency, March 1978).

**Roger J. Sullivan, Winder M. Heller, and E. C. Aldridge, Jr., Candidate U.S. Civil Defense Programs, System Planning Corporation Report 342, ARlington, Virginia, March 1978.

In defining and analyzing the civil defense postures, it was assumed that a "bolt from the blue" attack is unlikely and that any attack would probably be preceded by several days or weeks of intense crisis. Thus, a one to two week "surge" period was assumed to be available during which preparedness could be enhanced. Obviously, Posture 5 which does not depend on this assumption would be more reliable, but also more costly.

The large-scale attack assumed for this analysis was considered to be an appropriate pessimistic scenario against which it would be reasonable to test potential U.S. civil defense postures. Assumptions made include the following:

1. The USSR initiates a first strike against the US military targets, industry, and population.
2. All the estimated mid-1980's Soviet intercontinental capability is expended except for a relatively small reserve force.
3. All weapons are surface burst to maximize damage to hardened targets and to maximize population killed by fallout.
4. Two major attack scenarios are used. In both, US military and industrial facilities are targeted. Additionally, in the first attack, the in-place population was targeted; in the second attack, the relocated population was targeted, assuming the Soviets had complete knowledge of US relocation plans.

People were assumed to be limited to shelters within about three square nautical miles, corresponding to about 30 minutes walking time. The people were assumed to stay in the shelters as long as necessary. For cases not involving crisis relocation, it was assumed that ten percent of the population would spontaneously

evacuate. For cases involving crisis location, it was assumed that 80 percent of the population in risk areas was relocated. The results of this analysis are shown in Figure 1-2.*

Although the calculations in this analysis are obviously scenario-dependent, it appears clear that substantial numbers of lives could be saved if sufficient time were available for an extensive relocation program. Retargeting the evacuees would increase fatalities, but the differences between an evacuation posture and one where there is fallout protection only would still be substantial. Blast/fallout protection for an in-place population could provide about the same protection as extensive relocation, and would do so with considerably higher confidence since it does not depend upon extensive warning, but would be extremely expensive.

With regard to plans for post-attack resource management, the Institute for Defense Analysis made the following evaluation, which appears to be as true today as it was then:**

> The present plans for resource management in the post-attack period are slightly modified versions of those implemented during World War II. They have some merit in that they did work when it was necessary to husband certain resources very carefully. There has been some improvement since that time: computers now permit planners to handle more information faster andmore accurately than during World War II. In spite of these advantages, every researcher who has examined the problem has rejected the official plans as unworkable at worst, and recovery retarding at best.
>
> The reasons for this general rejection of the National Plan vary. Some economists, such as Morganstern and Hirshliefer, simply do not believe

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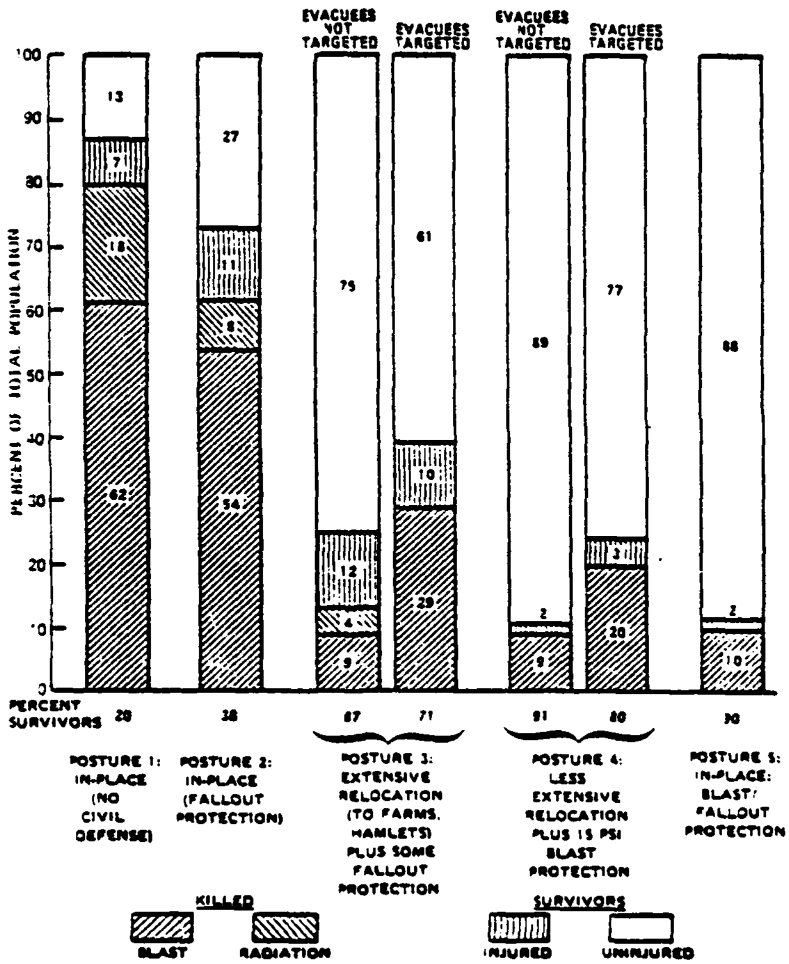
*ibid.

**Wayne Allen, Joseph Domin, and David Patterson, A Technical Examination of Alternative Civil Defense Programs (Arlington: Institution for Defense Analysis, November 1969), pp. 65-66.

FIGURE 1-2

CASUALTY CALCULATIONS FOR ATTACK AGAINST MILITARY AND INDUSTRIAL FACILITIES, PLUS POPULATION



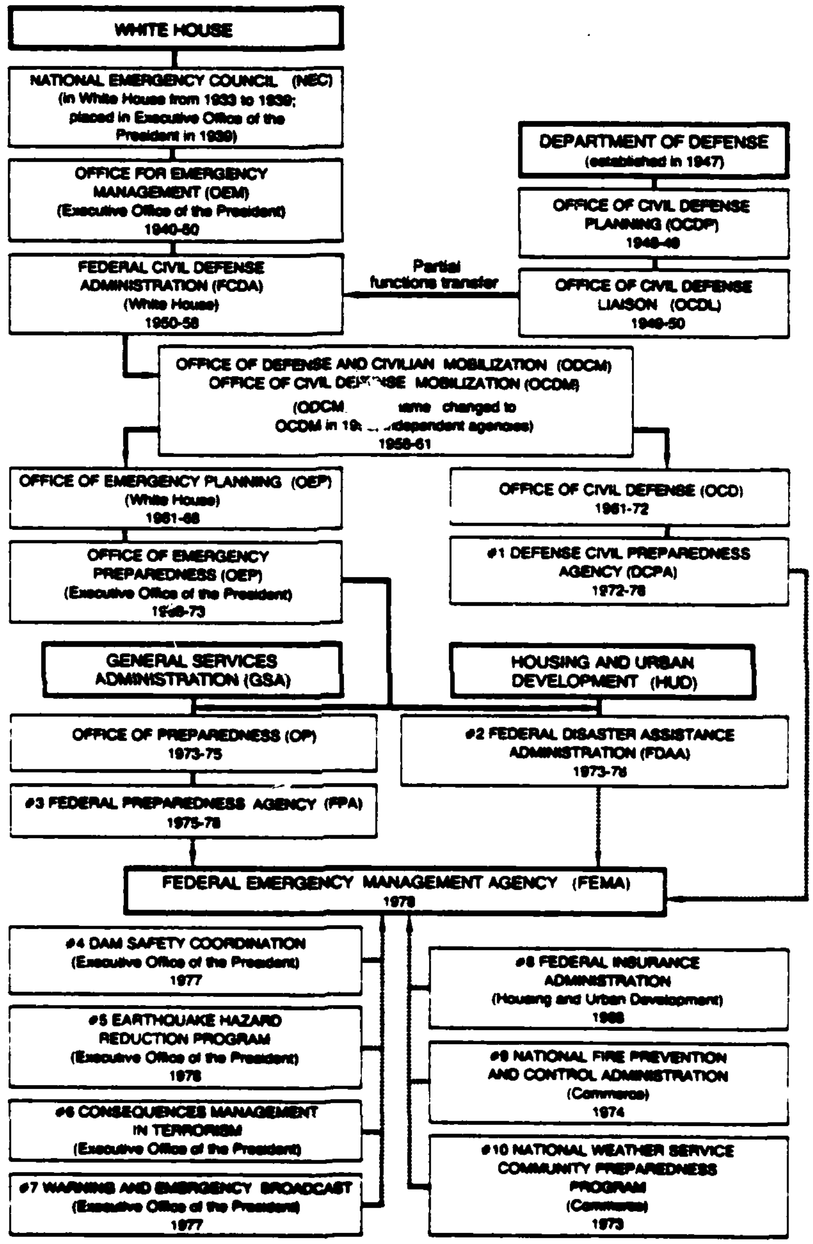
> centralized economic controls can be made to work under any circumstances. Other writers, such as Winter, Brown, and Kahn, have rejected the official plans because they are not suitable for the kinds of problems to be expected. The official plans may also be rejected on purely theoretical grounds (i.e., the post-attack situation will not meet the assumptions underlying this type of economic control, except for attacks that lightly damage the economy).
>
> In spite of this general rejection of the existing plan for managing economic recovery, there has been no consensus reached with respect to possible alternatives. Each of several authors has looked either in-depth at some narrow aspect of the problem (e.g., legal problems or insurance) or at its very general aspects, but in both cases with little or no recognition of previous work by other authors. The results have failed to show the evolution of ideas toward a consensus that is necessary for solutions to compelx problems. Many of the significant economic questions relative to currency reform, distribution of scarce goods and services, debt moratoria, and loss compensation have been ignored or are discussed only in generalities.

The organizational history of U.S. civil defense and emergency management is shown in Figure 1-3. The bottom portion of the figure depicts the organization of the Federal Emergency Management Agency.

In June 1978, President Carter submitted to Congress a plan to reorganize the Federal Government's emergency preparedness and disaster response organizations. This plan is now effective, and the various agencies and functional elements have been formulated into the Federal Emergency Management Agency (FEMA). The new agency replaced five existing agencies and assumes six additional disaster-related responsibilities. This places responsibility in one agency for all Federal programs involved in preparedness, mitigation, and response to national emergencies ranging from natural and man-made disaster to nuclear attack. The agencies include:

FIGURE 1-3

FEDERAL EMERGENCY ORGANIZATIONAL DEVELOPMENT*

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*From Comprehensive Emergency Management, A Governor's Guide, National Governor's Association Center for Policy Research, Washington, D.C., May 1979.

- THE DEFENSE CIVIL PREPAREDNESS AGENCY (Defense Department), which administers the National civil defense program.
- THE FEDERAL DISASTER ASSISTANCE ADMINISTRATION (Housing and Urban Development), which coordinates and funds Federal natural disaster relief operations.
- THE FEDERAL PREPAREDNESS AGENCY (General Services Administration), which coordinates civil planning for National emergencies.
- THE FEDERAL INSURANCE ADMINISTRATION (Housing and Urban Development), which manages the flood insurance and hazard reduction programs.
- THE NATIONAL FIRE PREVENTION AND CONTROL ADMINISTRATION (Commerce Department), which administers the Federal fire prevention program in coordination with State and local governments.

The six additional responsibilities to be assumed by the Federal Emergency Management Agency are:

- The community preparedness programs for weather emergencies, administered by the NATIONAL WEATHER SERVICE (Commerce Department);
- THE EARTHQUAKE HAZARD REDUCTION PROGRAM, Office of Science and Technology (Executive Office of the President);
- THE DAM SAFETY COORDINATION PROGRAM, Office of Science and Technology (EOP);
- THE FEDERAL EMERGENCY BROADCAST SYSTEM for oversight responsibility, Office of Science and Technology (EOP); and

- Emergency functions not now assigned to any specific Federal agency: coordination of emergency warning and Federal response to consequences of terrorist incidents.

The reorganization is aimed toward achieving the following objectives:

- Making a single agency and a single official accountable to the President and Congress for all Federal emergency preparedness, mitigation, and response activities.
- Creating a single point of contact for State and local governments, who have strongly urged consolidation of Federal emergency programs. (The Carter reorganization plan was endorsed unanimously by the National Governors' Association.)
- Enhancing the dual use of emergency preparedness and response resources at all levels of Government by taking advantage of the similarities in planning and response activities for peacetime and attack emergencies.

The current U.S. program does not include provision for physical protection of key industrial installations, either by peacetime actions or by planning for actions to be taken during a crisis.

Enhanced interest in U.S. emergency management has been evidenced at both the state and Federal executive levels. The National Governors' Association has this year published Comprehensive Emergency Management: A Governor's Guide, and four companion volumes resulting from the Association's 1978 Emergency Preparedness Project. Much attention in this guide is given to Federal-State relations during emergencies.

At the Federal level, interest arose in 1978 in the form of Presidential Decision 41 (PD 41) which directed that a new civil defense policy be implemented along the following guidelines:*

- that the United States civil defense program should enhance the survivability of the American people and its leadership in the event of nuclear war; thereby improving the basis for eventual recovery as well as reducing vulnerability to a major Soviet attack;
- that the United States civil defense program should enhance deterrence and stability, and contribute to perceptions of the overall U.S./Soviet strategic balance and to crisis stability, and also reduce the possibility that the Soviets could coerce us in times of increased tension;
- that the policy not suggest any change in the U.S. policy of relying on strategic nuclear forces as the preponderant factor in maintaining deterrence; and
- that the program include planning for population relocation during times of international crisis as well as be adaptable to help deal with natural disasters and other peacetime emergencies.

As a policy statement, PD-41 did not expressly contain any program details or associated budget decisions; however, the underlying study for PD-41 outlined program options and their associated costs. One option stressed crisis relocation, the civil defense program alternative which the Secretary of Defense had decided

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*Ralph L. Garrett, op. cit.

to implement starting in FY 1980, subject to policy budget and review.

The President's policy decision is that civil defense capabilities are a factor to be taken into account in assessing the strategic balance. The FY 1980 budget request represented a start on developing capabilities consistent with this policy.

Support for civil defense has been demonstrated over the past 20 years by surveys.* Support has been shown in these surveys for civil preparedness programs such as fallout shelters, blast shelters, and evacuation.

Congressional support has not equalled the levels of either recent Presidential or public survey support. In May 1979, the U.S. Senate Committee on Armed Services** recommended authorization of $106,800,000 for civil defense for Fiscal 1980, a cut of $2,000,000. Perhaps the comment that explains the committee's decision is: "Any conclusions as to the appropriatness of a future civil defense program of the magnitude being discussed within the Administration are premature. The committee intends to monitor closely the policy and program development of the civil defense program to assure it is reasonable and contributes to our overall national security."

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*See Ralph L. Garrett, op. cit., and J. Nehnevajsa, Issues of Civil Defense: Vintage 1978--Summary Results of the 1978 Survey, University of Pittsburgh Center for Social and Urban Research, 1979.

**U.S. Senate Committee on Armed Services, 96th Congress, First Session, Authorizing Appropriations for Fiscal Year 1980 for Military Procurement, Research and Development, Active Duty, Selected Reserve and Civilian Personnel Strengths, Civil Defense and for Other Purposes, Report 96-197, May 31, 1979, pp. 119-120.

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CIVIL PREPAREDNESS AND POST-ATTACK U.S. ECONOMIC RECOVERY. A ST--ETC(U)

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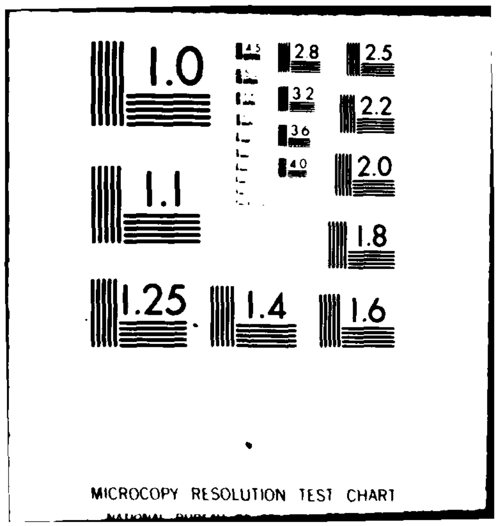
1.0
2.8
2.5
3.2
2.2
3.6
4.0
2.0
1.1
1.8
1.25
1.4
1.6
MICROCOPY RESOLUTION TEST CHART

Given this congressional view, the remarks of Joseph Romm a decade ago seem especially cogent:

If a new or accelerated civil defense program is to succeed, it must have as many of the characteristics below as possible:

- Contribute to defense posture
- Have a peacetime dual-use
- Have moderate cost
- Have the majority of its funding from the Federal Government
- Not attempt to involve the public too deeply or for too long a time

and most importantly,

- Must have continuing active support of the President, not to "sell" the general public, but to convince the Congress.*

Senator Proxmire's closing statement on the civil defense hearings of the Senate Committee on Housing, Banking and Urban Affairs delivered on January 8, 1979, sums up some of the problems with the present civil defense program. In that statement, Senator Proxmire says:

> The conflicting testimony from our expert witnesses and government spokesmen during this hearing points out very clearly that the United States still does not have a coherent, understandable, civil defense program. ...There is general agreement, even among

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*Joseph Romm, <u>An Overview of Political, Social and Public Acceptance of Civil Defense</u>, Systems Sciences, Inc., 1969.

> those who strongly disagree on other issues, that a modest program might make sense--a program of population evacuation planning. It does make sense--a program of population evacuation planning. It does make whatever measures are practical to save our civilian population if war should break out and to protect against natural and man-made disasters such as terrorist attacks. But is it practical?
>
> Will more planning make it possible to map out how our populous East Coast will evacuate and live off the land outside the metropolitan areas? Can we solve the transportation, food, medical, law enforcement, and electric power requirements for such a mass migration? Would people actually leave? Would they obey the plan? Would industry really cooperate by providing food stocks and transportation vehicles? Doesn't such a system need to be tested and if tested, what would that do to our strategic relationship with the USSR? Would it snowball into a nationwide shelter system costing $60 billion?

Senator Proxmire raises a number of key questions about the effectiveness of the crisis relocation program. The majority of the questions he raises can be addressed with research or analysis programs. However, a number of major issues and unresolved questions remain.

As can be seen from the brief analysis given in this discussion, one to two weeks warnirg could make a tremendous difference in the survival possibilities facing the nation. A feeling for the likelihood of this amount of warning might be obtained from looking at possible war initiation scenarios, but there is no way to know with any certainty whether such warning would actually occur. A political decision is needed to determine whether this country is to base its civil defense program on the availability of one to two weeks warning. Even if it were decided to do so, an additional decision is needed to determine whether this country will continue to rely on such warning, or whether it will begin to take measures (such as the slanting of new construction to provide

blast protection) which would provide protection for population in place.

The current civil defense program as well as the alternative postures discussed in this section deal only with the protection of people. The major issue still remains whether the U.S. civil defense program should protect things other than people. One issue that has been addressed in some the the recent civil defense debates is the protection of industry. No convincing analysis is available which will tell us how much and what kind of industry, if any, should be protected, nor is there any consensus on the feasibility of doing so. But a larger issue about protecting more than just people remains. If we accept the broad definition of civil defense, there is a long list of organizational capabilities and recovery management capabilities that must be preserved. There is no reason to believe that preserving these capabilities would be inordinately expensive. Yet very few of the measures in the current civil defense program address the preservation of these capabilities.

## 1.8 SOVIET CIVIL DEFENSE

Although this report is pointed toward U.S. civil defense and post-attack economic recovery, there are several reasons for reviewing the literature on Soviet civil defense. One is that it offers certain reference points against which to examine U.S. civil defense (e.g., the effectiveness of industrial hardening*). Also, assessments of both the magnitude and effectiveness of Soviet civil defense vary widely. Analysis of this spectrum of views of Soviet civil defense may well provide insights into the analysis of U.S. civil defense and post-attack economic recovery. Although not addressed here, the study of both U.S. and Soviet civil defense is pertinent to strategic analysis, and strategic analysis impacts the assumptions used for U.S. civil defense and post-attack economic recovery.

Views of the magnitude and effectiveness of Soviet civil defense vary widely. The effectiveness measures themselves vary from considerable to moderate to doubtful. The literature reviewed next is sequenced from moderate to considerable and finally to doubtful effectiveness.

The greatly increased pace of the Soviet civil defense program, beginning in the early 1970's, has led to an increased concern within the U.S. government about the impact that this program might have on the strategic balance. As a result of this concern, an inter-agency committee was formed to evaluate the Soviet civil defense. The summary of the results of this committee was prepared by the Director of Central Intelligence in July of 1978

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*T. K. Jones, Industrial Survival and Recovery After Nuclear Attack, Boeing Aerospace Company, Report D180-20236-1, 1976.

and entitled Soviet Civil Defense.* It provides a middle view of Soviet defense. The status, purpose, and relations within overall Soviet civil defense are covered in the following extract:

> Civil defense in the Soviet Union is an ongoing nationwide program under military control. The Soviets' strategic writings integrate civil defense into their military strategy. It is part of a general scheme of the likely origins, course, and consequences of nuclear war. The Soviets' experience in World War II and their traditional emphasis on homeland defense reinforce their interest in civil defense. By developing an active and extensive civil defense, in conjunction with their other defensive and offensive strategic programs, they hope to convince potential enemies that they cannot win a war with the U.S.S.R. If war should occur, the Soviets seek through civil defense along with other means to assure survival of the homeland and to leave the U.S.S.R. in a stronger post-war position than its adversaries. Civil defense is meant to contribute to the maintenance of a functioning logistic base for continuing military operations, to help limit human and material lossess, and to help enable the Soviets to speed recovery from the effects of nuclear war.
>
> The Soviet civil defense program is not a crash effort, but its pace increased beginning in the late 1960s. Civil defense activities are directed by a nationwide civil defense organization consisting of over 100,000 full-time personnel located at all levels of the Soviet government and economic structure. While improvements have been made in virtually all facets of the program, it has been marked by wide variations in implementation from area to area and year to year.. Bureaucratic difficulties and apathy on the part of a large segment of the population have retarded implementation in the past, though in wartime such problems would probably diminish. A sustained effort has been made to provide blast shelters for the leadership and essential personnel. Programs to protect industry by geographic dispersal have not been implemented to a significant extent, however, and there is little evidence of hardening of economic installations.

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*Director of Central Intelligence, Soviet Civil Defense, NI 78-10003, July 1968.

Objectives of the Soviet civil defense program are regarded to be:

-- An ability to protect people - the leadership first, the essential work force second, and the remainder of the population third.

-- An ability to protect the sources of economic productivity, to assure the continuity of economic activity in wartime, and to permit the restoration of production following a nuclear attack.

-- An ability to sustain the surving population in the period immediately following a nuclear attack, and to prepare for longer term post-attack recovery.

The authors of this report assessed the state of Soviet civil defense preparations with respect to these objectives and found with regard to the protection of people:

-- <u>Leadership</u>: The Soviets probably have sufficient blast-shelter space in hardened command posts for virtually all the leadership elements at all levels (about 110,000 people). Some of these shelters are harder than those available to the general population. All fixed leadership shelters which have been identified are vulnerable to direct attack, but we assume that alternative arrangements are available to protect at least the top leadership.

-- <u>Essential Work Force</u>: Shelters at key economic installations could accomodate about 12 to 24 percent of the total work force. However, Soviet plans do not call for sheltering the entire work force. In a crisis, nonessential and off-duty workers would be evacuated. Only those required to maintain essential production would remain behind to be sheltered. If one-half the total work force is dispersed, from 24 to 48 percent of the remainder could be sheltered.

-- Population: A minimum of 10 to 20 percent of the total population in urban areas (including essential works) could be accomodated at present in blast-resistant shelters. By 1984, the percentage of the urban population that could be sheltered would rise to 15 to 30 percent, assuming no change in the present rate of shelter construction. Despite the scope and pace of shelter construction, the absolute number of city dwellers not afforded such protection by 1985 will increase because of the expected population growth in urban areas.

The critical decision to be made by the Soviet leaders in terms of sparing the population would be whether or not to evacuate cities. Only by evacuating the bulk of the urban population could they hope to achieve a marked reduction in the number of urban casualties. An evacuation of urban areas could probably be accomplished in two or three days, with as much as a week required for full evacuation of the largest cities. These times could be extended by shortages in transportation, other bottlenecks, or adverse weather conditions.

With regard to protection of the economy, the report found:

> Soviet measures to protect the economy could not prevent massive industrial damage. The Soviet program for dispersal of industry appears to be offset by a contrary tendency for investments in new facilities to be inside or near previously existing installations. The Soviet measures for protecting the work force, critical equipment, and supplies and for limiting damage from secondary effects could contribute to maintaining and restoring production after an attack. We expect some improvements in the level of protection for the economy, but any radical change in its vulnerability to nuclear attack is unlikely.

and as for post-attack recovery:

> The operating elements of the civil defense program as well as substantial number of the civilian population (a number we cannot estimate with confidence)

have received training in rescue and recovery operations such as administering first aid, clearing rubble, decontaminating, and providing emergency repair and restoration of power. With at least several weeks to build up reserves and distribute supplies of food and fuel, the Soviets could probably provide adequate supplies to sustain the relocated and surviving urban population in the period immediately following a nuclear attack. Nevertheless, the coordination of requirements with available supplies and transportation is a complex problem for Soviet planners even in peacetime, let alone following a large-scale nuclear attack. We have not evaluated the potential for continuity of the Soviet government or the U.S.S.R.'s long-term ability to recover from the effects of a nuclear attack.

Estimates of the costs of Soviet civil defense were made.

While total civil defense costs are unknown, cost estimates have been made of three major elements of the Soviet program: pay for full-time civil defense personnel, operation of specialized civil defense military units, and shelter construction. The cost of these elements in 1976 amounted to about 400 million rubles, less than 1 percent of the estimated Soviet defense budget. If these three elements of the Soviet program were to be duplicated in the United States, they would have cost about $2 billion in 1976, with about three-fourths of this representing manpower costs. (These estimates should be considered rough approximations. They are affected by uncertainties both in the quantitative data on civil defense programs and in estimates of prices.)

The effectiveness of Soviet civil defense on levels of damage and casualties from an attack, and for coping with the post-attack period were assessed to "depend primarily on the time available to make preparations before an attack." Depending on the assumptions casualties ranged from the low tens of millions to well over 100 million.

The continued confidence the Soviets have in their civil defense was explained:

> The Soviets almost certainly believe their present civil defenses would improve their ability to conduct military operations and would enhance the U.S.S.R.'s chances for survival following a nuclear exchange. They cannot have confidence, however, in the degree of protection their civil defenses would afford them, given the many uncertainties attendant to a nuclear exchange. We do not believe that the Soviets' present civil defenses would embolden them deliberately to expose the U.S.S.R. to a higher risk of nuclear attack.
>
> Present evidence does not suggest that in the foreseeable future there will be any significant change in the Soviet leaders' judgment that civil defense contributes to war-fighting and war-survival capabilities, nor that their uncertainties about its actual effectiveness would be lessened. Thus, we have no reason to believe that the Soviet leaders' perception of the contribution of civil defense to their capabilities for strategic nuclear conflict will change significantly.

The final sentence implies that the Soviet leaders perceptions of that contribution of civil defense will neither increase nor decrease significantly.

Apparently the Soviets have <u>always</u> held that civil defense will make a major strategic contribution to their capabilities for strategic nuclear conflict, and they have proceeded with an orderly and organized program, accelerated in the early 1970's, to build a civil defense capability which will protect their population and the means of production in the case of a nuclear war. Thus, the issue is not what the Soviet aims might be, but whether they have the ability to carry out those aims.

The CIA report on civil defense gives an indication of present-day Soviet capabilities for civil defense. The civil defense capabilities reported on in this summary are, however, only a lower bound on the actual Soviet civil defense capabilities, because they are based only on evidence which is subject to national means of verification. This means that they do not take into account the many reports by emigrés and defectors

which indicate that the Soviet civil defense capability is much greater than that stated in the CIA report. Thus, we are certain that the civil defense effort reported on by the CIA exists. It is probable that the Soviet effort is much greater than this, but it cannot be verified by national means alone.

Although we do not know the capability of the Soviet civil defense effort, and perhaps we can never know it short of an actual nuclear conflict, we can get an estimate of its capability by observing the amount of effort that the Soviets are devoting to civil defense.

A substantial increase in Soviet civil defense efforts began in 1972, right after an ABM treaty was signed. The Soviet civil defense was put on a par with the other services of the Soviet armed forces. Today, the Soviet civil defense organization is a part of the Ministry of Defense and is headed by Deputy Minister Colonel-General Aleksander Altunin. Under his command are 70 to 80 general officers who serve as civil defense chiefs in the 15 Soviet republics. The permanent full-time staff of the civil defense organization numbers over 100,000 and this staff would be augmented during period of crisis. Civil defense training is compulsory for all Soviet citizens. In addition to an extensive civil defense training program, there has been a large program of building blast and fallout shelters for protecting the population.

There is little doubt that the Soviets have an extensive evacuation plan, although some analysts have questioned its efficacy. The issue of in-place shelters, however, is still being debated. The CIA report states that the Soviets have sufficient shelter for virtually all the leadership elements (about 110,000 people) and that they could probably shelter about 12 to 24 percent of

the total work force at key industrial installations. They also estimate that between 17 and 34 percent of the population of cities of more than 100,000 people can be protected by blast shelters.

Gouré, basing his estimates on published Soviet references to existing shelters and local shelter capabilities over the years, photographs of such shelters, reports by travelers, and data provided by recent Soviet emigrees obtains a somewhat different picture of Soviet shelter availability.* Gouré states that:

> Despite uncertainties, it appears realistic to assume that at this time sufficient shelter space exists for some 60 percent of the Soviet urban population in the potential target cities, and for at least 70 percent of those elements of the population which the Soviet authorities view as valuable or essential for the preservation of power and the recovery of the Soviet Union in the event of a war.

Gouré's estimates of the annual expenses for construction of protected facilities is on the order of two billion rubles, in contrast to the CIA annual estimate of 400 million rubles for civil defense, 60 percent of which was for construction.

Looking at another report where the effectiveness of an aspect of Soviet civil defense was rated high, civil defense for industry was assessed by T. K. Jones.** The resulting report addressed two questions regarding civil defense:

1. Can Soviet industry be effectively protected by the methods described in the Soviet literature?

2. Is it feasible to apply similar concepts to protect and ensure post-war recovery of U.S. industry?

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*Leon Gouré, Shelters and Soviet War Survival Strategy, University of Miami, Advanced International Studies Institute, Coral Gables, Florida, (9) 8.

**T. K. Jones, op cit.

The work done for this report led to affirmative answers to both questions.

On the less impressed side of Soviet civil defense assessors, the Arms Control and Disarmament Agency (ACDA) recently conducted an analysis of civil defense.* The unclassified summary of this study reports that:

> The Soviet civil defense organization has published several books and manuals, a number of which have been translated into English by U.S. agencies. These publications as well as other open source references to the Soviet civil defense program depict a system which is broad in scope and devoid of gaps, in conceptual terms. An assessment based wholly on Soviet literature would greatly overestimate the reality as well as the effectiveness of the system.
>
> The most tangible aspect of the Soviet civil defense program is the presence of hardened underground shelters. At the present time the Soviets are believed to have blast shelters for most of their leadership. In-place protection is estimated to be sufficient for ten to twenty percent of their urban population, based on a shelter space allowance of 1.0 and .5 square meters of floor space respectively. ACDA believes that $.5M^2$ is unrealistic due to the expected extended shelter stay times that would be required. Note that $.5M^2$ is equivalent to a square that is only 28 inches by 28 inches.
>
> The Soviets have developed plans for evacuation of the urban areas. These plans consist of transporting the urban population by rail, motor vehicles or on foot to relocation sites in rural areas. In the rural areas the urban population is to be housed with rural hosts and to be protected from fallout by upgrading the protection of existing buildings or by the construction of expedient shelters. Although the Soviet Union has never tested a large-scale city evacuation, it was assumed in the analysis presented here that 80 percent of the urban population could be evacuated.

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*United States Arms Control and Disarmament Agency, An Analysis of Civil Defense and Nuclear War (Washington, D.C.: December 1978).

> The Soviet Union has plans for the protection of industry. Despite these plans, however, there is little evidence of industrial dispersal or hardening. The reason for this lack of action is undoubtedly the huge cost and limited effectiveness of such measures. The only major Soviet accomplishment in the industrial protection area is the building of shelters for part of the work force. In addition, there is a program for the training of civil defense workers.

The ACDA report notes the following factors relating to civil defense:

- The extreme radiation doses (up to 30,000 roentgens) in the urban areas.
- The large casualty rates for people located in even very hard blast shelters.
- The fact that people that survive blast would have to stay in shelters for weeks or months.
- The shortage of food and water which would force many people to leave shelters.

With regard to civil defense, the ACDA report concludes that:

> While some civil defense activities, such as evacuation, have some effect on the immediate post attack environment, their benefits in the long run have not yet been established.
>
> Any attempts at industrial hardening would be of little use in view of the fact that detonating weapons at lower altitudes can create immensely greater levels of blast overpressure. Furthermore, future U.S. weapons systems would offset one and on-half to threefold increased in hardness.
>
> While people were not targeted, human fatalities from the attacks were still immense, on the order of 100 million from the prompt effects alone, without civil defense. In-place shelter protection could reduce the fatalities by 20 percent, but this effect would be offset if the strategic

forces were put on generated alert. Evacuation of the urban areas, if it can be implemented, would substantially reduce the fatalities from short-term effects to the order of 25 to 35 million in the Soviet Union. However, weapons could be used against the evacuated population with ground bursts, causing as much as 70 to 85 million fatalities in the Soviet Union even if the Soviet evacuation and sheltering plan is fully implemented.

Critics of the ACDA report contend that:

- The ACDA report assumes that the Soviets will not follow their stated civil defense plans. For example, it would be more reasonable to assume that (1) the Soviets would fill their high quality urban shelters to maximum occupancy rather than leave unevacuated people without adequate protection; (2) the Soviets would evacuate all persons for whom no adequate space was available. If they wish to leave larger numbers of people in the cities, they will build more high quality shelters rather than leaving the non-evacuees in a vulnerable condition.

- The ACDA study assumes that from one-third to two-thirds of the evacuees did nothing to protect themselves from fallout. If the Soviets allow a week or two surge period, the evacuees should be fully protected. Tests by Oak Ridge National Laboratories have shown that American families can construct fully adequate fallout shelters in 24 to 36 hours.

- If the Soviet population has been evacuated and protected in expedient shelters as planned, the ACDA conclusions that the use of weapons which are ground burst against the evacuated population could cause as much as 70 to 85 million fatalities in the Soviet Union would be substantially incorrect. Calculations by Boeing indicate that with 70 percent evacuation, the total fatalities would be about 17 million. Even if the total U.S. reserve force is added to this attack, these fatalities would increase to only about 27 million. The principal

reason for the difference between these figures and those of ACDA is that ACDA assumed the evacuated population will remain relatively clustered in populated places and that no allowance is made for the inherent blast protection of expedient shelters.

- The ACDA report assumes that the Soviet would not execute their stated plan to protect industrial components. The Defense Nuclear Agency and Boeing have demonstrated beyond any doubt that simple burial measures can offer dramatic protection for industrial equipment.

- The ACDA report assumes that when people leave the shelters they stat in the high intensity fallout areas. This leads them to conclude that supplies in the shelters are inadequate. Even in the highest intensity fallout areas, two-week shelter stay time would be adequate if people were assumed to spend 24 hours walking out of the fallout area after they left the shelter. Soviet civil defense manuals stress the mapping of safe areas and selection of emergency exit routes through contaminated areas so exit routes should be known when people leave the shelters.

- According to the ACDA study, 126 million Soviets are housed in an area of 5,000 square miles. However, to attack this urban population, an area considerably greater than 5,000 square miles must be covered. Efficiency of weapon coverage is decreased by the non-housing areas within the effective radius of each weapon. Map studies indicate that coverage of two to three times the actual residential area is needed to cover the area with real weapons.

In summary, no matter whose calculations about the effectiveness of the Soviet civil defense program one is inclined to believe, there no longer appears to be any doubt that a large Soviet civil defense program exists and has existed for a considerable number of years. There also appears to be little doubt that the Soviet place great strategic importance upon civil defense if a nuclear war occurs. There also is some evidence that the Soviets believe that their civil defense effort contributes to deterrence of an

attack by the United States. It is beyond the scope of this paper to speculate on the impact that the Soviet civil defense program has on the strategic balance. We can conclude, however, that the Soviet civil defense program is real, it is extensive, it is considered to be a significant strategic capability by Soviet leaders, and Soviet civil defense capabilities can be expected to continue to grow.

Clearly, a number of issues and unresolved questions exist with regard to Soviet civil defense and its effectiveness. One major question concerns the extent of Soviet blast shelters. If Gouré's sources are correct, the Soviet blast shelter program is considerably greater than that estimated by the CIA, and Soviet expenditures on civil defense are several times greater than those estimated by the CIA. A second question concerns industrial hardening. Soviet manuals indicate that the Soviets intend to harden industrial equipment during crisis periods. It is unlikely that we will ever have hard evidence that the Soviets will follow these intentions, since no evidence is likely to exist prior to a major crisis. Nevertheless, if the Soviets intend to harden industrial equipment, the effect on U.S. targeting and on the effectiveness of a U.S. attack could be substantial. Therefore, the extent of Soviet industrial hardening is a major unresolved question and is likely to remain so. Finally, there remains the major unanswered question as to why the Soviets are apparently implementing a major civil defense program.

## 1.9 MANAGEMENT ASPECTS OF POST-ATTACK U.S. ECONOMIC RECOVERY

The review of the literature described in the preceding sections followed by considerable analysis led to the identification of eight significant management aspects of civil preparedness and post-attack U.S. economic recovery. These are:

1. resource allocation;
2. resource distribution;
3. energy supplies and distribution;
4. information, communication, command and control;
5. finance (money and credit);
6. social and behavioral responses;
7. authority of government; and
8. alternative civil preparedness actions.

These management aspects provide opportunities for insight, analysis, policies and decisions to aid in management of the post-attack U.S. economy. The degree to which these aspects have been studied previously varies greatly. Resource allocation and to a lesser extent distribution of resources have received the earliest and greatest attention of those items listed. Recent events causing much concern with regard to current energy problems have yielded some analysis and a little modeling* with specific consideration of energy. The literature reviewed here, especially in the area of industry studies, has underlined the importance of energy considerations in analyzing and modeling the management of the post-attack economy.

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*See R. C. Dullien, E. A Hudson and D. W. Jorgenson, <u>The DRI Long-Term Inter-Industry Transactions Model</u>, Data Resources Inc., March 1977.

Since management decisions and policies require information, communication, command and control ($C^3$) in order to be executed, information and $C^3$ must be incorporated in analysis and modeling. While better hardware than heretofore is now available, potential post-attack disruptions to information flow make protection of such hardware extremely vital.

In 1968, Dresch recognized and cited information needs for post-attack decision-making and noted the expected difficulty in obtaining such information under post-attack conditions.* Yet in the decade since this paper, no efforts to explicitly include information and $C^3$ within post-attack recovery models were evident to this reviewer.

Perhaps equally crucial as information to post-attack economic recovery are financial arrangements. If an inefficient barter system is to be avoided, then plans for post-attack banking, monetary and credit arrangements are vital. Several alternative post-attack financial operations are discussed by Quester.** These financial considerations should be incorporated in post-attack recovery modeling though they have not been as yet.

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*Francis W. Dresch, Information Needs for Post-Attack Recovery Management, Stanford Research Institute, SRI Project Number MU-6294, April 1968.

**George H. Quester, Options for Accelerating Economic Activity After a Nuclear Attack, Report AAC-TR-9203/79, Analytical Assessments Corporation, July 1979.

Social and behavioral responses following nuclear attack have received some study.* The importance of understanding these responses for managing post-attack survival and recovery is widely admitted, but no efforts to incorporate these responses in recovery models was made until the recent effort by Pugh-Roberts.**

One of the most significant behavioral response questions is what percentage of people will evacuate when requested by officials. Studies of the September 1979 Gulf Coast hurricane Frederic induced evacuation and the March 1979 Three Mile Island nuclear power plant incident could shed much light on evacuation responses even though Three Mile Island did not result in a formal evacuation command.

Another key management aspect that needs to be studied within the context of post-attack economic recovery is that of government authority. This needs to be studied with regard to both level of authority (local, state, regional and Federal) and degree of authority. The likely destruction of previous government centers in a nuclear attack makes analysis of alternative surviving government centers important in regard to all of the management aspects previously cited. For example, it may have

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*e.g., W. W. Chenault et al., Social and Behavioral Factors in the Implementation of Local Survival and Recovery Activities, Human Sciences Inc., HSR-RR-67/12-Ip, August 1967.

**Pugh-Roberts Associates, Inc., DCPA Quarterly Progress Report No. 2, 1979.

a great impact on post-attack recovery whether surviving resources are managed, i.e., allocated and distributed by local, state, regional or Federal authorities.

An area for management decisions and policies that affords pre-attack actions involves alternative civil preparedness actions. These possible actions include shelter programs, relocation programs, stockpiling, warning systems, and plans for emergency government operations. The costs of most of these possible actions are not difficult to determine but the post-attack effects are exceedingly hard to quantify.[*] Incorporation of civil preparedness actions into post-attack economic recovery models would provide civil defense planners a structured means of assessing the impacts of alternative actions.

The difficulty and significance of the management aspects of post-attack recovery have been well cited. For example, Sobin noted in 1970 that effective management of surviving resources is as critical as the physical capabilities of these resources.[**] Perhaps one of the strongest expressions of the importance of management aspects is given by Pettee when summarizing the two UNCLEX-73 case studies:

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[*] See for example, James C. Pettee, Unclassified Nuclear Case Lesson Example of 1973 (UNCLEX-73), Volume II, National Survival After UNCLEX-73, Federal Preparedness Agency, November 1978.

[*] B. Sobin, Post-Attack Recovery, Research analysis Corporation, RAC-P-51, June 1970.

> The most serious threat to national survival reflected in these two case studies probably lies in the tremendous institutional improvisation and reconstitution requirement which must be met by a severely reduced governmental structure.*

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*Pettee, op. cit.

## 1.10 MODELING NEEDS OF POST-ATTACK U.S. ECONOMIC RECOVERY

In simple terms the two basic modeling needs for post-attack recovery models are that they be useful and relatively inexpensive. The latter is easier to define and measure, and with current budgetary limits, perhaps a decision-oriented statement of recovery modeling's objective would be to maximize usefulness to civil preparedness planners subject to meeting development cost restrictions. Although hard to define, some aspects of model usefulness can be listed as follows:

1. Decision/Policy Orientation
2. Flexibility
3. Realism
4. Comprehensiveness
5. Speed of Response.

If an economic recovery model is to actively help civil preparedness planners, it must afford them the opportunity to examine alternative decisions and policies. Thus, the model must be oriented toward that end. It should also provide insights and directions for civil preparedness.

The useful model must be flexible as well. It must be able to incorporate new aspects without undue difficulty, including the managerial aspects described in section 1.9. Also, it should be capable of handling differing levels of detail in separate portions of the model. Thus, aspects introduced into the model would not always have to be as detailed as well-structured aspects.

The realism of a post-attack recovery model is a very difficult attribute to assess. Yet, there are several items of realism not widely incorporated into prior models that would make them more realistic. These items include: nonlinear and dynamic

relationships; the management aspects cited before; separate time phases for survival, reorganization and recovery; and the allowance for multiple regions with varying damage levels and post-attack transfers of people and goods.

The comprehensive model must include all significant aspects that could impact model results and thus inferences drawn from these results. The drive toward comprehensiveness must be tempered by the need for quick response, i.e., of development and of execution. Including too much may delay both the model's initial availability as well as its response time when operational.

## 1.11 MODELING METHODS FOR POST-ATTACK U.S. ECONOMIC RECOVERY

The major modeling methods previously and currently used for modeling post-attack economic recovery include: input/output, econometric, optimization and system dynamics models. The first three of these were discussed in depth in section 1.3 of this report in the context of post-attack recovery modeling efforts. Much less coverage of system dynamics was provided in that section. Hence, the focus here is on system dynamics and its contrasts with these three other modeling methods plus assessment of all four of these methods with the modeling needs cited in section 1.10.

System dynamics was developed by Forrester in the late 1950's as a means of analyzing the structure and operations of industrial firms.* Originally termed industrial dynamics, a dynamic structural model was first developed for the Sprague Electric Company. This model focused on the flow over time of orders, work force, inventories, order backlogs, production rates, and other variables. The model incorporated feedback loops and indicated that the system was unstable in several respects, with wild oscillation of production rates, work force and inventories among other factors.

Forrester applied the system dynamics methodology to broader social systems in his Urban Dynamics and World Dynamics books in 1969 and 1971, respectively. Most recently, Forrester's

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*Jay W. Forrester, Industrial Dynamics, MIT Press, 1961.

efforts have been directed, with the aid of Nathaniel Mass on their National Economic Model.* Urban Dynamics focused on the problems of cities with building blocks of housing, labor, business and industry. World Dynamics contained structural relationships among the major subsystems of nonrenewable resources, population, agriculture, capital and industrial output, services and pollution. Forrester used his world model to study the effects of exponential growth on the use of resources in which the levels of the resources are assigned finite limits. Although the timing varied, all of Forrester's world model runs ended in disaster. These disastrous results were echoed in the popularized book, The Limits to Growth.**

The attention and critical response to these exercises of world models were both strong and numerous.*** The public debate was acrimonious and lengthy. The modeling efforts were criticized for their content, structure and assumptions.

Economists were in the vanguard of world model critics, with special emphasis on the lack of data or empirical content in the models. Also responding were "counter-modelers," people

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*Jay W. Forrester, "Changing Economic Patterns," Technology Review, August-September 1978, pp. 47-53.

**D. L. Meadows et al., The Limits to Growth, Universe Books, New York, 1972.

***See M. Greenberger, M. A. Crenson and B. L. Crissey, Models in the Policy Process, Russell Sage Foundation, New York, Chapter 6, for detailed documentation of the debate.

who took the world models, changed some assumptions and structure and achieved far less pessimistic results.*

Management scientists have long been sparring partners for Forrester and his system dynamics followers. Forrester himself flung down the gauntlet first in Industrial Dynamics when he described previous Management Science efforts as predominantly exercises in formal logic of little use to top management.** Another source of antagonism for both management scientists and economists were the immodest claims of superiority and wider applicability for system dynamics.

From this schism between system dynamics and other fields including economics and management science have come several trends that narrow the gap. To summarize these trends briefly, one must consider:

1. wider system dynamics usage and research beyond Forrester and his direct followers;
2. increased attention to detail in system dynamics models;
3. tempering of claims from system dynamics analyses;
4. much greater concern with validation of system dynamics models.

The wider system dynamics usage is evidenced by recent books written outside Forrester's immediate circle.*** Also, the System Dynamics Group in December 1978 listed system dynamics

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* ibid., p. 170

** Industrial Dynamics, op. cit.

*** Viz., R. G. Coyle, Management System Dynamics, John Wiley and Sons, 1977 and P. C. Roberts, Modelling Large Systems, John Wiley and Sons, 1979.

research efforts at 24 institutions outside of MIT. This spread of system dynamics research serves not only to widen interest but to separate criticism of Forrester's work from that of system dynamics efforts.

The expanded attention to detail in system dynamics models is evidence in Forrester's own work. His 1971 World Dynamics model had but five level variables while his current National Economic Model has on the order of 5,000 equations.

One source of great criticism of Forrester and system dynamics was the immodesty of the claims made. In 1971, one of these claims for his world system model was, "Therefore, this is the model I should use for recommending actions."* As a contrast, in his 1978 article on his National Economic Model, Forrester states:

> The System Dynamics National Model is a step toward better understanding of socio-economic systems. The Model has now reached a stage at which it can begin to show the reasons for previously puzzling economic behavior. Experiments can now be conducted in search of more effective corporate and national policies.**

The much increased concern with validation of system dynamics models has been shown in several different works. Forrester and Senge outlined a variety of non-statistical tests for system dynamics models.*** These tests covered model structure,

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*Forrester, <u>World Dynamics</u>, op. cit., p. ix.

**Forrester, <u>Changing Economic Patterns</u>, op. cit., p. 53

***Jay W. Forrester and Peter M. Senge, <u>Tests for Building Confidence in System Dynamics Models</u>, Report D-2926-3, System Dynamics Group, Sloan School of Management, MIT, December 1978.

model behavior and policy implications of the model. Their definition of testing involves "the comparison of a model to empirical reality for the purpose of corroborating or refuting the model." Successful model testing can be seen as leading to successful model validation. Peterson has suggested statistical methods based on optimal filtering for use with parameter choice and validity in system dynamics.* Though the validation gap remains, it is somewhat narrower.

System dynamics appears to have the capability of handling all of the management aspects of the post-attack U.S. economic recovery analysis (see section 1.9) including such hard-to-model items as social and behavioral responses and authority of government. The other modeling methods studied lack the capability of handling several of the management aspects of post-attack economic recovery.

Further, system dynamics meets the modeling needs of post-attack economic recovery modelers. As cited in the previous section, these include: orientation toward decision and policies, flexibility, realism, comprehensiveness and response speed.

The big stumbling block to acceptance of system dynamics for post-attack recovery modeling seems to be validation. Two possibilities look promising for overcoming this block. One possibility is to invite counter-modeling, i.e., let the critics try some model runs with their assumptions. Another, very

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*David W. Peterson, "Statistical Tools for Systems Dynamics," in The System Dynamics Method, Proceedings of the 1976 International Conference on System Dynamics, Geilo, Norway, edited by Jørgen Randers and Leif Ervik.

intriguing possibility is cross-validation of a system dynamics model with other model types. This would require prior agreement on test cases and exemplar scenarios plus a suitable forum for comparison and discussion of results.

## 1.12 DEFICIENCIES IN THE STATE-OF-THE-ART

This study has revealed several pertinent deficiencies in the present state-of-the-art of modeling and analysis involving civil preparedness and post-attack economic recovery. To summarize these deficiencies, it appears that a comprehensive, decision-oriented, realistic and flexible model is not yet extant, nor has the analysis related to such a model been done. The bulk of the research on civil preparedness and post-attack economic recovery has been fragmented, rather than wholistic, as illustrated by the major topic headings of this report. In addition, many aspects that are difficult to quantify and support with data have been neglected.

To discuss some of these deficiencies more specifically, a good place to begin is the heretofore limited scope of the state-of-the-art. That is, since analysis and modeling linking civil preparedness and post-attack economic recovery have been lacking, it has been difficult to quantitatively assess the impact of alternative civil preparedness policies on post-attack economic recovery. With this lack, costs of civil preparedness have been far easier to quantify than benefits, thus limiting comparisons of civil preparedness alternatives to civil preparedness costs and post-attack casualties.*

Another side of the limitation in scope has been the difficulty in varying attack scenarios. Without this capability, most studies have been limited to attacks comprised of a single

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*For example, see J. Pettee et al., PONAST II, Office of Civil Preparedness, 1972, or Roger J. Sullivan et al., Civil Defense Needs of High Risk Areas of the United States, Final Report SPC 409, System Planning Corporation, Arlington, Virginia, March 1979.

salvo fired over a short time span. There has been little effort directed toward protracted firing or those involving multiple periods of attack.

A concomitant result of the limitation in scope of the state-of-the-art is the absence of a decision-orientation for analysis of civil preparedness and post-attack economic recovery. Most studies and models have been descriptively oriented, i.e., given a set of inputs and assumptions, find what is expected to occur. In contrast, a decision-oriented study would be directed toward the comparison of alternatives for management actions or the identification of the best of competing alternatives.

Although generally due to resource limitations and choice of modeling approach, the lack of realism in the analyses and models reviewed has several facets to it. One of these is the omission of significant management aspects of post-attack economic recovery. Some of these management aspects are information, communication, command and control ($C^3$) systems, and financial systems. Another is the omission of "soft" aspects such as behavioral and social responses. The post-attack response of people to government requests is a pertinent example of such an aspect. The third facet of the lack of realism in the modeling efforts reviewed is that of oversimplifying assumptions such as linearity and static time frame. More realistic modeling efforts would permit both nonlinearities and dynamic effects to be incorporated.

The final area of deficiencies in the state-of-the-art concerns the lack of flexibility of prior models. This rigidity has made reactions to changing circumstances quite slow, with responses to inquiries considerably delayed.

## 1.13 SUGGESTED IMPROVEMENTS IN THE STATE-OF-THE-ART

The improvements suggested for the state-of-the-art of modeling and analysis for civil preparedness and post-attack economic recovery are directed toward remedying the deficiencies cited in the preceding section. Thus, suggested state-of-the-art improvements are modeling and analysis directed toward the development of a comprehensive, decision-oriented, realistic and flexible investigative tool for study of civil preparedness and post-attack recovery.

Perhaps most important, yet most difficult, would be the development of a model that linked civil preparedness and management of the post-attack economy. Such a model should be decision-oriented, i.e., allow the assessment of civil preparedness and post-attack management alternatives. It should be realistic without being cumbersome. Elements of realism to be included are management aspects and social and behavioral aspects as described in the preceding section. Also, to be realistic, a model should permit nonlinearities and dynamic responses.

Model flexibility should be enhanced to easily permit changes in assumptions and quick responses to inquiries.

In order to model some of the hard to quantify aspects such as social and behavioral responses, some additional basic research on these responses in crises should be done. Recent disasters that could be examined for insights into human behavior during disaster are the Three Mile Island, Pennsylvania nuclear power plant failure of March 1979 and the Alabama, Mississippi and Florida Gulf Coast destruction of Hurricane Frederic in September 1979. Of particular interest is the behavior in regard to evacuation from the disaster area.

Another improvement in state-of-the-art modeling of management of post-attack economic recovery would be the capability of modeling several regions with varying damage levels so that transactions between regions could be studied. Post-attack interactions between regions has not been explored via modeling.

The suggested state-of-the-art improvements involving modeling could be carried out by continued development of system dynamics models begun during FY 1979 for analysis of post-attack economic recovery and civil preparedness. The system dynamics models could be developed by progressively increasing their complexity to accomodate the improvements suggested here.

## 1.14 CHOICE OF MODELING APPROACH

After reviewing the literature on civil preparedness and post-attack economic recovery, describing management aspects, detailing modeling needs and modeling methods available, listing deficiencies and suggested improvements in the state-of-the-art, it appears that system dynamics should be selected as the central modeling approach. Although there are many reasons for this choice, most are encompassed by the general statement that system dynamics, of the modeling methods reviewed, best meets the needs of modeling civil preparedness and post-attack economic recovery.

Some of the features of the problem to be modeled that cause system dynamics to be an especially useful technique are:

1. The problem is embedded in a large, complex system;
2. the problem has important feedback loops;
3. dynamic effects must be studied;
4. nonlinear relations are involved;
5. relations among systems elements can be described; and
6. soft items such as behavior and management can be modeled.

Perhaps the most important single reason for the choice of system dynamics is its flexibility. This flexibility is manifested not only in the ability to handle the items listed above, but in the capability of permitting varying levels of detail in different portions of the model. Detail can be extensive where research interest is intense while a higher level of aggregation can be used where interest is less. Also, system dynamics can handle multiple geographic sectors or regions, each with its own degree of damage. This is an important capability for evaluating post-attack resource allocation policies, and an improvement over input/output models which do not have regional submodels.

The flexibility of system dynamics that permits varying the level of detail in the model allows investigations of model structure without requiring large volumes of data. This advantage of system dynamics is due to its process orientation as opposed to data orientation.

A feature of system dynamics that follows from its allowance for dynamic effects is the capability of incorporating delays. Delays that could be modeled include delays in physical movements, management decisions, communications, and organization.

It is suggested here that system dynamics be selected as the central modeling approach. It may well be desirable to employ other methods for determining the inputs to the system dynamics model or to assess the outputs from it. For example, an optimization model may be useful for selecting civil preparedness options to be input to the system dynamics model. Further, a *decision analysis* model could be used to rank post-attack management policies based on results output from the system dynamics model. In such cases, it would not be onerous to link the central system dynamics model with the other model segments.

## 1.15 CRITICAL ISSUES FOR FUTURE INVESTIGATION

There are many issues in the subject area that could benefit from further analysis and model development. These issues include a variety of investigations of alternative civil preparedness and emergency management policies and post-attack economic recovery. These suggested investigations involving both analysis and further model development, are discussed in turn.

First, continued analysis is needed of the use of information, communication, command and control ($C^3$) systems in post-attack survival and economic recovery management. Post-attack management will need good information to make good decisions and carry out policies yet the post-attack information and $C^3$ system is likely to seriously weakened unless protection is undertaken. Thus, further research should test the concept of a hardened emergency information and $C^3$ system that could be used for a variety of disaster situations as well as for post nuclear attack analysis. Such an information and $C^3$ system should be incorporated into post-attack economic recovery modeling efforts so that the impact of the emergency information and $C^3$ system on post-attack recovery can be assessed.

Another important task for investigation is further determination of the scope of post-attack economic management problems. This study could be carried out by analysis and development of a model designed to assess the effects of alternative post-attack resource management policies. Resource management here should be taken in a very general sense to include transportation, human and financial resources as well as the more obvious stocks of raw materials, goods, equipment, buildings and energy.

The analysis of post-attack economic recovery should incorporate the impacts of both mobilization and post-attack national

security requirements. This could be accomplished by further analysis and inclusion of pre-attack mobilization and post-attack national security requirements, i.e., police and military needs, into an extended post-attack economic recovery model.

A post-attack recovery model should allow for multiple regions with varied damage and trade between regions. This would take recognition of the expectation of non-uniform damage across the country and facilitate analysis of alternative resource movement policies.

Continued research on civil preparedness and post-attack economic recovery should incorporate additional social and psychological factors for greater realism in analysis and modeling. Factors to be investigated should include: responsiveness to government requests such as those to evacuate or to share limited resources; and behavior and productivity in times of severe dislocation and stress. Factors such as these would have a significant impact on post-attack recovery.

In order to broaden the spectrum of situations the post-attack recovery model can accommodate, the analysis and modeling efforts should be extended to comprehend a variety of targeting and war scenarios. An important war scenario that has received little attention heretofore is protracted war. Targeting possibilities for study include counter-force, counter-value, counter-leadership, counter-recovery, and selective targeting, plus mixed strategies.

Another extension to the model should allow the testing and ranking of alternative civil preparedness policies. Candidate policies for stockpiling, post-attack resource allocation, information and communication, command and control, and pre-attack

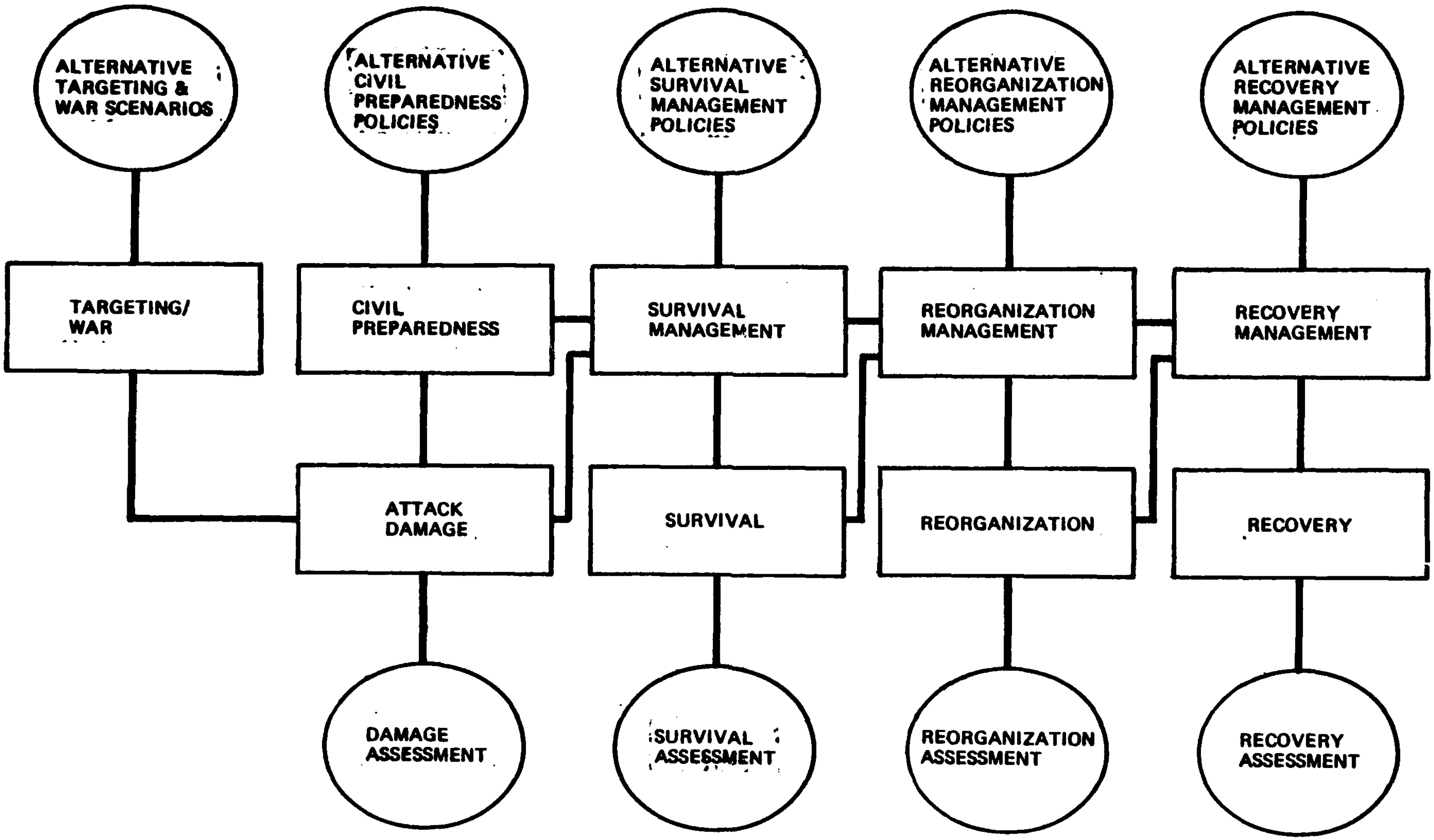
hardening and mobilization could be assessed and ranked in order of preference. This effort would reveal top-ranked candidate policies by considering resources used, strategic economic and social benefits, and implementation difficulty.

With all of the above mentioned suggestions for further investigation, it would be important to assess the effects of uncertainty on post-attack economic recovery. This might be done by systematically varying key parameters throughout the model. The results of such an investigation would provide a sensitivity analysis for the alternative policies and targeting and war scenarios studied. However, there are many effects which cannot be modeled without including actual distributions of such things as delays. Thus, an untimate objective should be to include stochastic effects in the model.

Taken together, these recommendations point toward analysis and the development of a comprehensive but not cumbersome model for the assessment of alternative policies for post-attack economic recovery. The diagram of such a model's key time phases is shown in Figure 1-4. Alternative input scenarios and policies are shown at the top of the diagram, while assessment of damage and the post-attack phases are displayed across the bottom. Future modeling and analysis efforts should continue to look for significant interactions between civil preparedness and management policies and post-attack recovery. A more comprehensive effort would be able to consider a wider range of possible difficulties and a broad spectrum of aids to recovery.

FIGURE 1-4

DIAGRAM OF AN ADVANCED POST-ATTACK RECOVERY MODEL
WITH ALTERNATIVE POLICY INPUTS AND ASSESSMENT OF RESULTS



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# SECTION II

# SELECTED ANNOTATED BIBLIOGRAPHY

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Wayne Allen, Joseph Domin and David Patterson, A Technical Examination of Alternative Civil Defense Programs, Institute for Defense Analysis, IDA Study S-360, November 1969.

This study examined the technological, systems, cost and economic aspects of five civil defense postures containing nine selected program options. It also reviewed problems of post-attack recovery.

The postures examined and the estimated ten year costs are as follows:

| | POSTURE | 10 Year Cost (All 1969 $) |
|---|---|---|
| 1. | Planning only | \$ 500 X $10^6$ |
| 2. | Limited protection for limited number of people (the current civil defense program) | \$ 570 - 1155 X $10^6$ |
| 3. | Limited protection for all people (full fallout protection with evacuation option) | \$ 1.7 - 2.5 Billion |
| 4. | Significant protection for limited number of people (blast and fallout) | \$ 5.1 Billion |
| 5. | Significant protection for all people (included evacuation to rural shelters) | \$ 6 - 16 Billion |

The study considered "slanted" or "dual-purpose" structures which are built for other purposes in which deliberate sheltering capacity is incorporated. There were no major problems seen with food and transportation, but problems with medical supplies and management were cause for concern.

This study's citing of management problems is still timely but its lack of concern with post-attack transportation is not, given anticipated petroleum system disruptions.

H. I. Ansoff and Dennis P. Slevin, "An Appreciation of Industrial Dynamics," Management Science, March 1968, pp. 383-397.

The authors claim that this paper is an "impartial appreciation" of Industrial Dynamics (later broadened into System Dynamics). Their views "were gleaned largely from published literature and to a smaller extent from conversations with practitioners." This could be interpreted as a weakness since the authors did not work with the technique themselves.

This paper, somewhat dated now, makes two excellent points as to what may have generated some of the greatest criticism and barriers to use of Industrial Dynamics. First, they cite that "Forrester and his followers have not been particularly modest about claims for the breadth and superiority of his discovery." This masterpiece of understatement was written prior to the publication of Urban Dynamics, World Dynamics, and The Limits to Growth! Second, they note Forrester's denigration of the value of management science models and economic models as aids to top management. An inference could be drawn from these points that more cautious claims for Industrial Dynamics with less antagonism by its proponents toward management science and economics may have earned fewer critics and more supporters. Extending this argument further, the System Dynamics model user who proceeds cautiously without throwing bricks at management science and economics may provoke less criticism than earlier System Dynamics efforts.

R. U. Ayres, Models of the Post-Attack Economy, Hudson Institute, Inc., HI-648-RR, August 1966.

This survey of studies of the post-attack economy of the U.S. identifies, describes, and critiques work done at Rand, the Institute for Defense Analyses, the Army's Engineer Strategic Studies Group, and the National Planning Association, and mentions some additional projects that were getting under way at the time of writing. The work subsequently done at the Research Analysis Corporation (by Bernard Sobin), the Stanford Research Institute (by Dresch and Baum), and the efforts that supported the PONAST II and UNCLEX-73 studies are too recent for inclusion.

Ayres comments that all such studies have tended to focus on those aspects of post-attack problems for which theoretical apparatus happened to be available, and that other aspects -- social, organizational, managerial, financial, etc. -- have in large part been neglected. (He cites as a partial exception the Rand work of Sidney Winter.) The upshot is that post-attack studies have generally had input-output orientiations. Ayres' critiques, then, are for the most part recitations of the limitations of input-output analysis as applied to heavily damaged economies.

He mentions that the input-output table at the heart of such models depicts the economy as it existed at one moment in time, revealing nothing directly about the presence of evolutionary processes or about the nature of those processes; he deplores the frequent ignoring of "lead times" (the time lapse between investment activities and consequent increases in product flow); he mentions that the extent to which an input-output model allows for substitutability is a by-product of the modeler's choice of the number of sectors into which to disaggregate the economy (unfortunately, the number of sectors chosen may be determined by quite different considerations); he notes that the interindustry coefficients are usually assumed to be rigidly fixed

even though that is clearly unrealistic; he points out that geographic aggregation is such as to rule out accounting explicitly for localized interruptions of the rail net, or for other forms of regional disruption; and, finally, he expresses dissatisfaction with the (typical) failure to handle demand considerations endogenously, as functions of supply, rather than mixing them up with exogenous policy considerations.

Ayres also mentions, but hardly does justice to the point, that there are data problems -- actually enormous data problems -- associated with input-output analysis, and that these have yet to be surmounted satisfactorily.

The list of major criticisms is already long enough so that one should clearly not want to stake too much on input-output models having predictive value in connection with post-attack recuperation. But one more criticism ought to be mentioned: obviously, one of the post-attack possibilities is that major shifts would take place in international trade. In particular, foreign production might, to some extent, fill in for production lost as a consequence of the attack -- probably not in every industry across the board, but perhaps at least in industries that would otherwise constitute bottlenecks. The extent to which that happened would, of course, depend upon many factors. But input-output models, as ordinarily used, take no cognizance of such shifts.

Howard M. Berger, A Critical Review of Studies of Survival and Recovery After a Large-Scale Nuclear Attack, R & D Associates, RDA-TR-107006-009, December 1978.

This report contains an overview and a selected annotated bibliography of 94 studies related to survival and economic recovery following a large-scale nuclear attack (some of these bibliographic entries are used again in this report). Topics covered include: historical lessons, industry studies, economic models, civil defense, and studies of post-attack viability, reorganization, recuperation and recovery.

The key assessment of this study is that post-attack viability ought to be studied further since viability is essential to recovery, while recovery is seen as not crucial since it follows viability. Viability was studied in the 1960's but then work was stopped since the general conclusion of these studies was that viability would not be threatened.

Although most studies were found to conclude that surviving resources following a nuclear attack would be adequate for viability, the management of those resources could pose a serious threat to survival and recovery. Critical to the management of post-attack resources are information and communication requirements and transportation capabilities.

Another critical issue seen is the lack of focus on potential instabilities. Instabilities could result from positive feedback mechanisms such as the relation between productivity and essential support items for workers. It is suggested that civil defense measures should be designed to counter attacks targeted to cause instabilities in the economy.

Berger recommends:

- work toward a consensus regarding assumptions, data bases, approaches and promising methodologies;
- capture the essence of the problem by simplifying its scope, i.e., build a hierarchy of models which are flexible in the level of detail in each segment, with separate phases for survival, reorganization recuperation and recovery;
- include financial, fiscal and monetary factors and societal consideration, even if not quantifiable to the same degree of precision;
- make the model decision oriented so it can help answer the desired questions; and
- use system dynamics to look at the management aspects associated with post-attack viability.

This report has been extremely useful for our study of the state-of-the-art of management of the post-attack U.S. economy. It has collected, summarized and analyzed a far-flung literature produced over a two-decade period. Its conclusions that the viability phase is the key to recovery, and that management is the key to viability, provide a valuable direction for continued research.

Howard M. Berger, The Effects of Nuclear War: Civil Defense - What It Can and Can't Do, Analytical Assessments Corporation, AAC-TR-10803/79, January 1979.

This was a one month summary effort for the Office of Technology Assessment (of the U.S. Congress) in analyzing the civil defense of both the U.S. and the U.S.S.R. Many other references were quoted, especially Nordlie and Vestermark, Gouré, various Russian civil defense works, and the ACDA reports. It describes civil defense measures, then discusses their effectiveness. Among the civil defense measures studied were blast shelters, fallout shelters, crisis relocation, industrial relocation and post-attack planning.

Briefly summarized: the Soviets have a large civil defense program, while the U.S. barely has one. Even Senator Proxmire thinks the U.S. needs to test the "big questions": Why are the Soviets spending so much on civil defense? What should the U.S. spend? How?

This report provides a recent, concise, and useful summary of both U.S. and Soviet civil defense and looks at opinions (often opposing) regarding directions and actions for the U.S. civil defense program.

John W. Billheimer, Frank J. Jones and Myron Myers, Food System Support of the Relocation Strategy, Part I: Analysis and Case Study; Part II: Prototype Plans; Part III: Planning Guidelines, Systan, Incorporated, September 1975.

This study covers different alternatives for the distribution of food to evacuated populations under crisis relocation conditions. It traces food stocks in existing distribution systems by magnitude and location. The most effective food distribution strategy under crisis relocation conditions is to allow agricultural output to follow normal distribution channels through major processing plants to wholesale warehouses which are then used as retail outlets and mass feeding stations. Colorado Springs was used as the case study. Problems include hoarding and transportation system stress. Assessments of the food stocks on hand are wholesale - three weeks; retail - two weeks; consumer level - two weeks.

A serious problem not addressed is how people are going to get to these wholesale warehouses when transportation will be severely disrupted. Often the wholesale food warehouses are large facilities located at greater than walking distance for much of the population of large urban areas.

E. B. Block et al, Initial National Survivability Study, Summary Volume, Stanford Research Institute, Technical Note SRD-EG34, October 1977.

This is a summary volume of a six-month study to gain insight for a follow-on study to estimate survival and recovery from nuclear war by the U.S. and the U.S.S.R. This summary includes a review of previous studies on national survival and recovery, a review of Soviet economic growth since World War II, an evaluation of stockpiles of strategic materials, and a pilot study of the U.S. aluminum industry in the post-attack environment.

In their literature review, they found consensus on basic necessities but lack of the same in defining an acceptable level of austerity. They did not find much on capital equipment required for rebuilding industry. Although studies of transportation facility damage were found, they did not find studies on post-attack transportation demand or fuel needs.

Their review of strategic materials showed that 53 of these did not then meet the three year stockpile goal. This was not surprising, since the goal had just previously been raised from one year.

Their study of the aluminum industry found it to be easily interrupted by a nuclear attack, but hard to destroy unless directly targeted. Among their discoveries is that solidified pots of aluminum are not ruined and can be restarted following a power outage. That electric power may not be available continuously, or in large quantities following a nuclear attack was not considered.

In addition to the summary volume, there were four appendices, two reviews of post-attack survival and recovery, one on pacing industries in the U.S.S.R., 1940-1990, and one on post-attack survival and recovery of the U.S. aluminum industry.

The review of economic recovery models and economic literature uses the Soviet Union as the basis for this review, even though extensive models of economic recovery in the U.S. are available and the primary purpose of this report was to analyze U.S. survival and recovery. The argument given for using the Soviet Union as the basis for the review is that actual data "although sparse and often inconsistent" are available for Soviet growth since WWII, and that the Soviet growth since WWII is representative of a recovering economy. It is questionable whether this growth would be representative of Soviet growth after a nuclear attack, since the needs of a developing economy are quite different from those of a recovering economy. Also it can be expected that government objectives and controls for a post-attack recovery period in the Soviet Union would be different from those used after WWII. Furthermore, the training and quality of the human assets in the Soviet Union at the present time is quite different from those that were present at the end of WWII. Applicability of these results to U.S. recovery is even more tenuous than the possible applicability to Soviet recovery. It is understandable why this approach was taken since the reviewers were intimately familiar with the SRI SOVMOD model of the Soviet economy and the post-war Soviet economic data needed for the running of that model. However, this appears to be a classical example of the analyst's propensity for studying what he knows how to study instead of studying what is relevant.

Harold Brown, Department of Defense Annual Report, Fiscal Year 1979.

This annual report requests a 3.5 percent increase over fiscal year 1978 spending and a 2.7 percent real increase each year to fiscal year 1983 in total obligation authority. It funds a modest (see page 44) civil defense effort consisting primarily of crisis relocation planning, shelter surveys, improved communications and emergency planning. It notes that Soviet strategy includes evacuating about 79 percent of the urban population.

The primary purpose is to significantly reduce the vulnerability of the U.S. population to a major Soviet attack (page 126). Additionally, "the program will provide for dual-use in peacetime emergencies as well."

The key to saving lives is crisis relocation of a major portion of the population. An R & D effort should emphasize planning for population relocation and also to develop and field-test potential low cost techniques for protection of essential industries.

Stephen L. Brown and Pamela G. Kruzic, Agricultural Vulnerability in the National Entity Survival Context, Stanford Research Institute, July 1970.

This reports on two separate studies of U.S. agricultural vulnerability to large-scale Soviet nuclear attack. One study tests several assumptions for their impact on damage assessment. Assumptions tested included: weight of attack, duration of assumed vulnerability, type of attack, and efficiency of attack. The most sensitive assumption turned out to be efficiency of attack, i.e., whether or not the attack is directed toward maximum damage to agriculture.

The second study was focused on a key agricultural input, fertilizer. In this study, trends in both the manufacture and use of fertilizer were considered. Most of the trends were found to be in directions that would increase the vulnerability of U.S. agriculture to Soviet nuclear attack. Most of these trends involved increased use of fertilizer in general, with an increasing application of special formulations of fertilizer.

One matter of concern with these studies is the age of the data used. In the first study, the data base dates from 1959 (p. 18) while in the second study it dates from 1968 (p. 75). Given the changes in American agriculture, two decades is a long time.

Agricultural vulnerability may be a moot topic, however. As these authors suggest, much greater efficiencies could be achieved by attacking the petroleum refining capacity with resulting damage nearly as harmful to agriculture and, in addition, crippling other sectors of the economy.

Stephen L. Brown and Ulrich F. Pilz, U.S. Agriculture: Potential Vulnerabilities, Stanford Research Institute, January 1969.

Brown and Pilz' report provides results for several "essentially independent studies on selected aspects of U.S. agriculture for the identification of potential vulnerabilities under nuclear attack." (p. iii) After studying the characteristics of fertilizer and pesticide application, cultivation and irrigation, farm use of petroleum and electricity, and beef cattle and poultry production, they found the implication that "the most serious sources of vulnerability relate to fertilizer and petroleum." On the other hand they found that "geographical imbalances between production, processing and distribution of food were not enhanced after the attacks postulated." Two attacks were used, one counter-force and the other mixed counter-force and counter-value.

They studied vulnerability of U.S. agriculture to nuclear attack for a variety of grains, alfalfa, potatoes and sugar beets. Although the worst attack date for each crop was different, they selected June 15 as a worst-case attack date for all crops.

They found that important agricutural practices included application of fertilizer and use of petroleum for farm machinery. Using 1964 data, fertilizer was found to be used on two of three farms, with use more prevalent in the East than in the West. They concluded that "even though farmers do not currently use maximum rates of fertilizer, the loss of fertilizer could have serious implications for U.S. agriculture." These implications are partly due to exhausting effects on the soil by crops such as corn.

With 1952 and 1958 data, Brown and Pilz found the use of large volumes of pesticides, herbicides, and fungicides based on petroleum. Pesticides were deemed important because they contribute to stability of crop production over a period of years.

They looked at irrigation with the aid of 1959 data and found only eight percent of all cropland to be irrigated, with most of that land in the eleven Western states and Hawaii. Without irrigation due to a shortage of electric power or damage to irrigation system, they thought that crop balance might be affected since potatoes, fruits and vegetables would be in short supply.

Farmers were found to use 8.6 million gallons of liquid fuel in 1959 which represented about ten percent of U.S. gasoline and diesel fuel production. The fuel was primarily for tractor use during the April-June period for tillage and planting. The recent movement by some farmers to plant without plowing (over stubble) may save considerable fuel.

Their conclusion with regard to petroleum and post-attack agriculture is: "Without attempting quantitative analyses we can state immediately that without petroleum, field crop production is virtually impossible in the United States system. All major food and feed crops are mechanically planted and harvested. In addition, as has already been discussed, the application of fertilizers and pesticides and cultivation also depend on petroleum-fueled machines." ... "The only historical substitutes for petroleum-fueled machinery are draft animals and manpower. Neither of these possibilities is feasible in the context of national entity survival." (p. 45)

Their outlook for post-attack food distribution was not nearly as gloomy. They concluded: "Because the pre-attack distributions of resources are so unbalanced relative to one another, however, the changes in the fraction of the national total supplied by each region (by as much as a factor of two) do not make correspondingly large changes in the imbalance." (p. 65)

The authors' conclusions with regard to the post-attack management of agriculture are still timely and pertinent to this study. On page 79 they state: "Management, as usual in post-attack studies, again seems to be the key to the whole agricultural situation during the post-attack period. Even though the combined effects of fallout radiation, petroleum shortages, and fertilizer deficiencies could stress the agricultural system, production is still likely to exceed minimum survivor demands. Because of extensive disruption of processing and distribution channels, as well as of the normal patterns of demand and supply, preattack market systems may not be sufficient to get food from producers to consumers in time. A postattack information and management system with the function of determining where resources are available and where they are needed would be desirable."

Brown and Pilz clearly did a comprehensive assessment of vulnerability of U.S. agriculture to nuclear attack. Many of their conclusions, e.g., regarding the importance of petroleum and management appear to be timely today, a decade after their report was published. A matter for concern, however, is their use of data from the 1950's to reach conclusions regarding petroleum, pesticides and fertilizers. The changes in uses of these materials over the past 20 years would seem to merit reconsideration of their use or

non-use in post-attack agriculture. Also, the crucial effects of a shortage of petroleum for agriculture were spotlighted during the spring of 1979.

W. M. Brown, Emergency Mobilization for Post-Attack Reorganization, Hudson Institute, HI-8742-RR, May 1968.

This report examines the problem of the early post-attack reorganization period, the interval in which surviving institutions would attempt to begin functioning in the new environment. It also studies countermeasures which can be implemented during a time of crisis through mobilizing the population for civil defense action. This review will deal with only the part of the report which examines the reorganization period.

The major finding of this study is that the threat to U.S. society during the reorganization period may be very great. An illustrative scenario where this threat is enormous is presented in the report. Components of this threat include work and family problems, unpaid bills, unreceived salaries, and currency dependence.

It is concluded that after a nuclear attack, before national recovery can begin, the country may need to emerge satisfactorily from a reorganization phase during which any surviving institution might have to establish a new "identity." This means that institutions must find ways to determine their post-attack functions, that is, to hire employees, obtain supplies and find outlets for their production, all within a new and possibly wildly changing system of prices, wages, rents, taxes and government influence. The government itself would have the problem of establishing its own "identity." If this reorganization phase is not successful, a rapid enough recovery to preserve or restore the economic viability of the country is not assured even though a major fraction of the physical resources survive a nuclear attack.

In addition to the above conclusions, the report also draws a number of conclusions about desirable pre-attack and post-attack civil defense efforts. The report suggests that "crisis orientation" is the appropriate framework to view countermeasures for both short-term recovery and long-term orientation. Included also in the report are appendices describing the Mongol invasion of Khorasan, and discussing crisis measures for post-attack industrial recovery.

William M. Brown, On Reorganizing After Nuclear Attack, Rand Corporation, Paper P-3764, January 1968.

This paper develops the thesis that even though a major fraction of the physical resources of a nation survives an attack, the economic viability of the country is not assured. To do this, this paper develops a grim scenario of the "intangible" problems which might develop. These intangibles tend to be socio-economic or politico-economic and affect institutions whether damaged or not. These problems are composed of such matter as:

- Loss of credit or solvency.
- Confusion as to property rights among survivors.
- Legal problems of debts and unfulfilled contracts.
- Meaningless wage contracts or salaries.
- Temporary collapse of the Federal Government or Federal authority.
- Temporary suspension of banking.
- Temporary suspension of the judicial system.
- Wild fluctuations in prices, rents, or expectation of future prices
- Civil disorder arising out of spurious distribution of surviving supplies
- Socio-political and economic uncertainties compounded by rumors and local breakdowns in law and order

The scenario presented in this paper is very unlikely to occur, but specific elements in this scenario provide the basis for thinking about pre-attack plans which could prevent many of these problems.

The author thinks that a low budget civil defense program could save up to 95 to 99 percent of the population (page 4). Effective economic reorganization is accomplished when:

1. certain elements of federal government are restored
2. functioning money system exists
3. manpower is available for emergency government functions.

To avoid post-attack social and institutional problems during a pre-attack crisis period:

1. stockpile
2. prepare to manage stockpile distribution after attack
3. prepare post-attack currency
4. develop civil defense mobilization teams
5. seize the food industry.

William M. Brown, On the Post-Attack Viability of American Institutions, Rand Corporation, Paper P-4275, January 1970.

This paper emphasizes the need for pre-attack planning for the survival of government, especially the federal government. Plans are needed for maintaining the money-personnel-authority loop. It goes through scenarios with and without federal government survival.

The proposed federal role includes:

1. Disseminate vital information
2. Clarify property rights
3. Restore a legal and political framework
4. Provide new investment policies and incentives
5. Establish a clear damage compensation plan

The discussion in this paper of the elements of this role suggest that these elements may be very difficult to carry out.

William M. Brown, Recovery from a Nuclear Attack, Written for the Office of Civil Defense, October 1971.

Brown, who has previously written about post-attack viability and vulnerability, develops a detailed scenario for a 1973 nuclear war. For the Soviet attack, he assumes the 1966 UNCLEX attack of 800 weapons totaling 4000 MT. Urban fatalities are assumed to be reduced by evacuation of 70 percent of the population of the 250 largest urban areas.

The federal and most State governments are destroyed with the nation fragmented into many autonomous political entities each with a unique set of problems. Scenarios are provided in detail for the early survival period and for a reorganization period of three months.

In his conclusions, Brown looks at the implications of increasing the number of survivor through urban evacuation, and finds both advantages and problems such as increased competition for surviving food, fuel, and housing. He is concerned that:

> a failure of the federal government to survive as an effective national entity during the first few months post-attack could lead to a severe fragmentation of the nation that might last for years, and seriously jeopardize a meaningful recovery of the national entity.

He suggests several low cost efforts that could facilitate civil defense crisis mobilization and enhance the prospects for post-attack survival and recovery. These suggestions are:

(1) Federal plans for increasing stocks of survival supplies during a nuclear crisis and dispersing them to protected locations in accordance with anticipated post-attack requirements.

(2) Federal plans to build a large paragovernmental organization rapidly during a crisis, one that could help it to manage the post-attack reorganization.

(3) Federal policies based on the above plans which would guarantee minimum subsistence needs to all survivors.

(4) A Federal policy for post-attack housing and political rights of refugees.

These four recommendations written nearly eight years ago appear to be still timely today. Although plans have been made for stocks of survival supplies, there do not appear to be plans for dispersing them during a crisis to protected areas. Current civil defense plans do provide a very high priority for continuity of government. Some recent detailed plans do provide for housing under crisis relocation conditions. Long term arrangements for post-attack housing have not been studied as thoroughly if at all.

Elwood S. Buffa and James S. Dyer, "Managerial Use of Dynamic Structural Models," Decision Sciences, Vol. 8, No. 1, January 1977, pp. 73-94, also included in their book, Management Science/Operations Research, Wiley/Hamilton, New York, 1977.

Buffa and Dyer provide a most readable introductory level explanation of System Dynamics under their term "Dynamic Structural Models" with illustrative examples, diagrams, and displays of graphic output. They also cover KSIM, another large-scale system simulation technique* and compare it with System Dynamics. They found KSIM easier to use but System Dynamics more flexible in modeling and in choosing the appropriate relationships.

This article briefly reviews World Dynamics and The Limits to Growth but spends more space on implications of "dynamic structural models" for managers. They state that:

> "Dynamic structural models have an important place in the world of models for they can deal with problems on a broad aggregation basis and provide a manager with an understanding of the effects of the interacting variables and of the dynamic aspects of how the system works." (p.91)

Their purpose in writing this survey article was aptly expressed in the abstract:

> "Dynamic structural models were introduced as early as 1958 as "Industrial Dynamics," but there has been little managerial use and little response in the academic world. Yet, the basic modeling methods provide an important

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*Kane, J., W. Thompson, and I. Vertinsky, "KSIM: A Methodology for Interactive Resource Policy Simulation," Water Resources Research, Vol. 9 (1973), pp. 65-79.

> mode for examining the broad interacting effects of large systems. More recent work appears to make structural and dynamic models understandable and accessible to individuals not trained in the decision sciences. The nature of the modeling methods is such that managers and policy makers in public systems can be involved directly in the model building process. The authors hope that this survey paper may help rekindle interest."

Despite their fond hopes for rekindled interest, Buffa and Dyer eloquently express one of the criticisms that has often been leveled at users of System Dynamics, namely that the model itself has not changed over time. They conclude:

> There are pitfalls in the interpretation of the effects of any model over long time spans. If one assumes a change in a sensitive parameter, the effect for a following year may seem plausible, but a fifty year projections of the effect through an amplifying feedback system may be astonishing. With such sensitive parameters, there is a "fulcrum effect" which multiplies the force on an effect when one projects results over long periods of time.
>
> Can one assume that any system's structure would remain stable over a fifty-year period? In The Limits to Growth study, for example, it is true that different assumptions were made and that the model was rerun with the new assumptions, but those assumptions and the model structure were static in the new run. What would happen, for example, if adaptive and flexible responses to changing world circumstances were built into the model? Such adaptive behavior is one of the prime characteristics of man and the actual behavior of the economy. To date, however, the term "dynamic model" has not meant that the model itself has changed over time. Perhaps such a change is the next needed development in methodology.

E. M. Bull, The Runout Production Evaluation (ROPE) Model: Structure and Methodology, American Technical Assistance Corporation, June 1973.

This report describes an interindustry model of the U.S. economy in the first ninety days after a nuclear attack. The model is designed to show the influences of constraints resulting from a government-imposed priority system in the absence of normal peacetime optimizing. The model is based on the U.S. Department of Commerce's 1958 input-output study. Each of the 86 sectors of the economy is assigned to one of two priority classes. In the model design **reported on,** the sectors assigned to priority one were those producing commodities on the List of Essential Survival Items, maintenance and repair construction, transportation, communications, public utilities, automobile repair, medical services and government enterprises.

Since the model covers such a short time period, it runs into trouble because it cannot distinguish between the current production that results in finished goods as opposed to current production still in the goods-in-process inventories of producers. One questions why all this effort for a ninety-day period should be expended unless it is believed that the ninety-day period is critical, and that it is so essentially different from the succeeding periods that it has to be treated separately. The only justification appears to be that this is the first step in a dynamic model of the post-attack economy and that subsequent time periods would be modeled starting with the outputs of the results for the first ninety days. However, there is no indication in the report that this is the case.

Elwyn M. Bull and Bernard Sobin, Measurement of Critical Production Capacities for Models of the Post-Attack Economy, Research Analysis Corporation, Technical Paper RAC-TP-387, February 1970.

This work reviews and evaluates prior published work on estimating post-attack capacities of individual industries. It describes and reviews these available capacity measures for suitability in post-attack economy models. It suggests an approach to improving the measures (mainly by expanding them) for such models and illustrates it through analysis of capacity to produce wheat flour. They conclude, "surveys of past model runs disclosed no satisfactory way to identify before a nuclear attack particular industry capacities that may be expected to be most critical after the attack." Industry capacity can be expanded by changing production methods, overtime and converting related industrial capacity.

This report reviews models of Clark, Bear and Clark, Fassberg, Igo and Moder, Peskin, Bickley and Pearsall (PARM), Sobin and Sanderson. Two areas of concern found are difficulty in choosing an appropriate level of aggregation and lack of full substitution possibilities.

It is worth noting that no consideration of fuel problems is evident.

W. W. Chenault, et al., Social and Behavioral Factors in the Implementation of Local Survival and Recovery Activities, Human Sciences Research Incorporated, HSR-RR-67/12-Ip, August 1967.

This report takes a socio-economic approach, attempting to combine the insights of economic and behavioral analysis in a single treatment of the recovery problem. This approach is based on the thesis that recovery management must make special provision for the fact that human resources are not passive elements in post-attack planning. Survivors must be motivated to support and participate in those post-attack activities required for economic recovery. That is, if post-attack plans are in fact to be implemented, they must be designed to take account of social and behavioral, as well as economic, factors in the post-attack environment.

This study draws the same conclusion that many other sutdies of disaster behavior draw; namely, that survivors would respond to disaster by reordering the priorities they assign to primary group and secondary group activities. Concern for the family would tend to be the most critical source of motivation. Survivors will not be motivated to contribute to national economic recovery until they believe that the maintenance needs of their immediate family group are satisfied. Unless recovery policies are specifically designed to take into account the different social backgrounds of the different communities in the nation, it is possible that local communities will resist participating in a national economic recovery effort, resulting in localized recovery efforts which are not optimum for the nation as a whole.

R. G. Coyle, _Management System Dynamics_, John Wiley and Sons, New York, 1977.

Coyle's text is oriented toward managerial problems and provides thorough coverage of System Dynamics methodology and several case studies. Coyle espouses the use of the computer language DYSMAP (Dynamic System Modeling and Analysis Package) developed by Coyle and his colleagues at the University of Bradford in England, rather than DYNAMO developed by Forrester and his colleagues at MIT. Coyle acknowledges his intellectual debt to Forrester, however.

Perhaps one of Coyle's most useful contributions is his list of fourteen questions to be answered as criteria for project selection. These questions are:

1. Is there any dynamic behavior?
2. Do the dynamics matter and why?
3. Are there any loops?
4. Are there any alternative system structures or control policies?
5. Can it be done?
6. What data and information are available?
7. Can we define the variables?
8. What are the dangers of oversimplification?
9. What level of aggregation is needed?
10. What facilities are needed?
11. What training will be required?
12. How much can we afford?
13. How long have we got?
14. How about implementation?

R. G. Coyle, "On the Scope and Purpose of Industrial Dynamics," International Journal of Systems Sciences, Vol. 4, No. 8, 1973, pp. 397-406.

Coyle looks at the developmenc and past use of system dynamics. He discusses the reasons for the lack of wider application of system dynamics and suggests some efforts that would encourage broadened usage.

Coyle's suggestions to encourage system dynamics applications include:

1. Expand the number of university centers doing teaching and research in this area;
2. Develop a more rigorous theoretical framework;
3. Build up a library of case studies;
4. Expand the available literature with books as well as papers and research reports; and
5. Improve the computational packages available for system dynamics beyond the DYNAMO compiler.

Coyle has taken action on many of his own suggestions. He has established a system dynamics research group at the University of Bradford in Great Britain, developed a compiler (DYSMAP or Dynamic System Modeling and Analysis Package), and written a book (included in this bibliography) to serve as a basic text with several case studies.

Defense Civil Preparedness Agency, Department of Defense, Draft Guidance for Crisis Relocation Planning in Highly Urbanized Areas, Draft CPG-2-8-17, October 1977.

This is a supplement to Parts I and II of the DCPA Guide to Crisis Relocation Contingency Planning (CPG-2-8-A and CPG-2-8-B). It covers relocation planning in detail for large urban centers having a population greater than one million. It uses New York as an example city, although 25 such centers are listed. The coverage includes:

- relocation flow
- transportation needs and resources
- assessment of hosting capacity
- aggregate and detailed transportation analysis via autos, buses, truck, air, rail and water.

The work concludes with detailed procedures for allocating evacuees to host areas, assuming a ratio of five. It uses the ADAGIO Program for allocating hosts. On pages 1 to 3, it allows a six hour period of official notice and a three day target for relocation but notes on pages 1 to 10 that this target may not be attainable for all areas. On page G-6, there is a plan for 100 percent relocation even if some people stay put or cannot be moved.

Defense Civil Preparedness Agency, Department of Defense, Government Authority and Continuity in Support of Crisis Relocation, Report RS-2-8-70, September 1978. Includes Part I - State and Part II - Federal.

PART I - STATE

This report was prepared by the council of state governments following two research efforts in 1975-1976. It summarizes the functions of host areas, risk areas, and state governments. It assesses the status of state laws vis-a-vis crisis relocation functions as of January 1, 1976. For example, only 32 states had legal authority to terminate crisis relocation. The report suggests state legislation to fill the gaps found. It provides sample executive orders. Among the alternatives summarized as useful for policy decisions is: "there is a need for stand by regional government for large metropolitan areas which would include strong executive powers and authority to assume operational control...Planning for crisis relocation for such areas should be strongly urged."

PART II - FEDERAL

This lists Federal Government functions including the President, Congress, and all Departments and agencies. It assesses the status of federal laws to carry out crisis relocation and continuity of government. After assessing current laws and crisis relocation legal needs, it is suggested that the Federal Civil Defense Act of 1950 be amended to handle a "National Emergency for Crisis Relocation of Population from High Risk Areas."

Alternatives useful for policy decisions include: the primary thrust of governmental actions at all levels will be to facilitate and support the continued functioning of existing commercial

systems for the distribution of food, fuel, pharmaceutical or medical supplies. An alternative is to nationalize these systems to insure continued distribution and to prevent hoarding.

Defense Civil Preparedness Agency, Guidance for Development of an Emergency Fallout Shelter Stocking Plan, Report CPG-1-19, July 1978.

Among the assumptions contained in this report are that there will be a period of international tension prior to the initiation of an attack, that water is the most crucial survival resource, and that shelter feeding will be austere and for survival only. Supplies discussed are water, food, sanitation requirements, medical supplies and sleeping and entertainment supplies.

Defense Civil Preparedness Agency, Guide for Crisis Relocation Contingency Planning: Overview of Nuclear Civil Protection Planning for Crisis Relocation, CPG-2-8-A, January 1979.

This guide provides an overview of the Nuclear Civil Protection (NCP) planning program. It is intended to aid NCP planners and state and local officials. The goal of NCP is to maximize the number of survivors of a nuclear attack. Decision-making officials have the two basic options of in-place protection and crisis relocation. These two options are interdependent because warning time and/or circumstances could preclude or limit crisis relocation.

About 400 high risk areas have been identified for purposes of crisis relocation planning. These include areas containing strategic offensive military forces, other areas of high military value and urban/industrial complexes with populations of 50,000 or more. It is assumed that Soviet weapons had a reliability of .9 and CEP of .5 nautical mile. Damages were assumed to be maximized by air-burst weapons with fallout maximized by ground burst.

This document provides an overview of Crisis Relocation Planning for Nuclear Civil Protection with a structure for additional detailed planning at the State and Local levels.

Defense Civil Preparedness Agency, Department of Defense, Guide for Crisis Relocation Contingency Planning: State (and Regional) Planning, Report CPG-2-8-B, January 1979.

This covers planning resources and planning philosophy, definition of risk areas, population allocation and assignment to hosting areas. It describes State Crisis Relocation Operations Plan and plans for support of food, transportation, fuel, health services, electric power, telecommunication, direction and control, and emergency public information.

Defense Civil Preparedness Agency, Department of Defense, Guide for Crisis Relocation Contingency Planning: A Prototype Risk Area Plan for El Paso County - Colorado Springs, Working Draft CPG-2-8-D-1, October 1976.

This guide describes a prototype plan for developmental and training purposes. It should not be interpreted as the official plan for the locality described. Included are: Situation and Assumptions, Mission, Execution, Direction and Control, Law Enforcement Service, Fire and Rescue Service, Health and Medical Service, Reception and Care Service, Resource and Supply Service, and Administration and Logistics. Features relocation planning with maps and contains much detail. On page 30, it is noted that "it is better to plan for 100 percent relocation" even though some may not relocate.

Director of Central Intelligence, Soviet Civil Defense, NI 78-10003, July 1978.

This is a summary of the results of an interagency committee formed to evaluate Soviet civil defense. This document provides a cautiously worded unclassified assessment of Soviet civil defense. The Central Intelligence Agency is somewhat less impressed with the magnitude and effectiveness of Soviet civil defense than are Leon Gouré and T. K. Jones (see entries by these authors in this bibliography) but still is considerably impressed.

The status, purpose, and relations within overall Soviet civil defense are covered in the following extract:

> Civil defense in the Soviet Union is an ongoing nationwide program under military control. The Soviets' strategic writings integrate civil defense into their military strategy. It is part of a general scheme of the likely origins, course, and consequences of nuclear war. The Soviets' experience in World War II and their traditional emphasis on homeland defense reinforce their interest in civil defense. By developing an active and extensive civil defense, in conjunction with their other defensive and offensive strategic programs, they hope to convince potential enemies that they cannot win a war with the U.S.S.R. If war should occur, the Soviets seek through civil defense along with other means to assure survival of the homeland and to leave the U.S.S.R. in a stronger post-war position than its adversaries. Civil defense is meant to contribute to the maintenance of a functioning logistic base for continuing military operations, to help limit human and material lossess, and to help enable the Soviets to speed recovery from the effects of nuclear war.
>
> The Soviet civil defense program is not a crash effort, but its pace increased beginning in the late 1960s. Civil defense activities are directed by a nationwide civil defense organization consisting of over 100,000 full-time personnel located at all levels of the Soviet government and economic structure. While improvements have been made in virtually all facets of the program, it has been marked by wide variations in implementation from area to area and year to year.

Bureaucratic difficulties and apathy on the part of a large segment of the population have retarded implementation in the past, though in wartime such problems would probably diminish. A sustained effort has been made to provide blast shelters for the leadership and essential personnel. Programs to protect industry by geographic dispersal have not been implemented to a significant extent, however, and there is little evidence of hardening of economic installations.

Objectives of the Soviet civil defense program are regarded to be:

-- An ability to protect people - the leadership first, the essential work force second, and the remainder of the population third.

-- An ability to protect the sources of economic productivity, to assure the continuity of economic activity in wartime, and to permit the restoration of production following a nuclear attack.

-- An ability to sustain the surving population in the period immediately following a nuclear attack, and to prepare for longer term post-attack recovery.

The authors of this report assessed the state of Soviet civil defense preparations with respect to these objectives and found with regard to the protection of people:

-- Leadership: The Soviets probably have sufficient blast-shelter space in hardened command posts for virtually all the leadership elements at all levels (about 110,000 people). Some of these shelters are harder than those available to the general population. All fixed leadership shelters which have been identified are vulnerable to direct attack, but we assume that alternative arrangements are available to protect at least the top leadership.

-- Essential Work Force: Shelters at key economic installations could accomodate about 12 to 24 percent of the total work force. However, Soviet plans do not call for sheltering the entire work force. In a crisis, nonessential and off-duty workers would be

evacuated. Only those required to maintain essential production would remain behind to be sheltered. If one-half the total work force is dispersed, from 24 to 48 percent of the remainder could be sheltered.

-- Population: A minimum of 10 to 20 percent of the total population in urban areas (including essential works) could be accomodated at present in blast-resistant shelters. By 1984, the percentage of the urban population that could be sheltered would rise to 15 to 30 percent, assuming no change in the present rate of shelter construction. Despite the scope and pace of shelter construction, the absolute number of city dwellers not afforded such protection by 1985 will increase because of the expected population growth in urban areas.

The critical decision to be made by the Soviet leaders in terms of sparing the population would be whether or not to evacuate cities. Only by evacuating the bulk of the urban population could they hope to achieve a marked reduction in the number of urban casualties. An evacuation of urban areas could probably be accomplished in two or three days, with as much as a week required for full evacuation of the largest cities. These times could be extended by shortages in transportation, other bottlenecks, or adverse weather conditions.

With regard to protection of the economy, the report found:

> Soviet measures to protect the economy could not prevent massive industrial damage. The Soviet program for dispersal of industry appears to be offset by a contrary tendency for investments in new facilities to be inside or near previously existing installations. The Soviet measures for protecting the work force, critical equipment, and supplies and for limiting damage from secondary effects could contribute to maintaining and restoring production after an attack. We expect some improvements in the level of protection for the economy, but any radical change in its vulnerability to nuclear attack is unlikely.

and as for post-attack recovery:

> The operating elements of the civil defense program as well as substantial number of the civilian population (a number we cannot estimate with confidence)

have received training in rescue and recovery operations such as administering first aid, clearing rubble, decontaminating, and providing emergency repair and restoration of power. With at least several weeks to build up reserves and distribute supplies of food and fuel, the Soviets could probably provide adequate supplies to sustain the relocated and surviving urban population in the period immediately following a nuclear attack. Nevertheless, the coordination of requirements with available supplies and transportation is a complex problem for Soviet planners even in peacetime, let alone following a large-scale nuclear attack. We have not evaluated the potential for continuity of the Soviet government or the U.S.S.R.'s long-term ability to recover from the effects of a nuclear attack.

Estimates of the costs of Soviet civil defense were made.

While total civil defense costs are unknown, cost estimates have been made of three major elements of the Soviet program: pay for full-time civil defense personnel, operation of specialized civil defense military units, and shelter construction. The cost of these elements in 1976 amounted to about 400 million rubles, less than 1 percent of the estimated Soviet defense budget. If these three elements of the Soviet program were to be duplicated in the United States, they would have cost about $2 billion in 1976, with about three-fourths of this representing manpower costs. (These estimates should be considered rough approximations. They are affected by uncertainties both in the quantitative data on civil defense programs and in estimates of prices.)

The effectiveness of Soviet civil defense on levels of damage and casualties from an attack, and for coping with the post-attack period were assessed to "depend primarily on the time available to make preparations before an attack." Depending on the assumptions casualties ranged from the low tens of millions to well over 100 million.

The continued confidence the Soviets have in their civil defense was explained:

> The Soviets almost certainly believe their present civil defenses would improve their ability to conduct military operations and would enhance the U.S.S.R.'s chances for survival following a nuclear exchange. They cannot have confidence, however, in the degree of protection their civil defenses would afford them, given the many uncertainties attendant to a nuclear exchange. We do not believe that the Soviets' present civil defenses would embolden them deliberately to expose the U.S.S.R. to a higher risk of nuclear attack.
>
> Present evidence does not suggest that in the foreseeable future there will be any significant change in the Soviet leaders' judgment that civil defense contributes to war-fighting and war-survival capabilities, nor that their uncertainties about its actual effectiveness would be lessened. Thus, we have no reason to believe that the Soviet leaders' perception of the contribution of civil defense to their capabilities for strategic nuclear conflict will change significantly.

The final sentence implies that the Soviet leaders perceptions of that contribution of civil defense will neither increase nor decrease significantly.

Joseph D. Douglass, Jr. and Amoretta M. Hoeber, Soviet Strategy for Nuclear War, Hoover Institution Press, 1979.

A review of Soviet military literature leads to a conclusion that the Soviet Union is prepared for a nuclear war and if one is fought will aim for complete destruction of enemy military capability. Of key importance to recovery of military capability cited (page 34) in the Soviet literature are: (1) electric power; (2) oil; (3) certain critical chemical industries; and (4) transportation.

Soviet military literature covers: (1) analysis of surprise and its use and prevention; (2) the role of strategic reserves in a nuclear war after front line and second echelon used; and (3) the importance of superiority.

The authors doubt the validity of the conclusion of those who believe that the Soviets would not strike first. The authors base their doubt on the foundation of Soviet military thought - laws, principles, tactics, strategy and doctrine.

Francis W. Dresch, Information Needs for Post-Attack Recovery Management, Stanford Research Institute, SRI Project Number MU-6294, April 1968.

This project contains a thorough discussion of information needs by the post-attack government. The recovery decision process would be complicated by the imposition of controls, the need for well directed investment, and the economic dominance of government public works expenditures. Also, in the post-attack period, information available would be restricted. It also mentions the significant consequences of targeting petroleum refining (pages 3 - 4). It uses some decision analysis terms for considering alternative actions. It considers tradeoff analyses. It concludes that pre-attack planning would help post-attack management.

This report is normative in the sense that it talks about what should be done and assumes that the information and organizations that are required will be able to do it. Sidney Winter in his paper "The Federal Role in Post-Attack Economic Organization," suggests that the reorganization of the government will not take place in time to provide the necessary information and decision-making. This reviewer is inclined to agree with Winter after seeing the enormity of the information and decision-making tasks facing the reorganized government that are displayed in this report. Even with a well-organized government, it is easy to envision delays, mistakes and gross uncertainties resulting from the novelty of the tasks undertaken and the enormity of the problems that exist in the post-attack economy.

This report does not attempt to develop a model which would show the impact of the informational needs on the restructuring of the economy. It is questionable whether such a model could be built, but it is certain that the principal impact of the lack of information will be to slow down the start-up of the economy and to reduce the efficiency of those parts of the economy that are able to get started. This report presents a very lucid description of the types of information that will be required, so it serves as a good starting point for estimating the inefficiencies which will result if that information is not made available in a timely fashion.

Francis W. Dresch, Methodology for the Analysis of the Vulnerability of Economic Institutions, Stanford Research Institute, SRI Project Number MU-6300-410, Final Report, April 1969.

This report contains an econometric model of the economic subsystem with consideration of financial and institutional substructure. It models the pre-attack subsystem first and projects to post-attack. It includes a discussion of demand, supply of basic resources (labor is critical), sources and use of funds, effects of tax and fiscal policy, lead times required in reconstruction, regional differences, and international aspects (imports and exports). The annotated bibliography of 17 references are mostly his own or Federal statistics. No crisis results are given.

Since data are not available on important elements of the problem, the study includes consideration of different gap-filling assumptions to explore the sensitivity of the economy to a range of conceivable alternatives. This is done through the use of economic sub-models, and by interpretation of the prelininary results in terms of conventional economic analysis.

The economy is disaggregated into nine industrial sectors and the 1958 data prepared by the Office of Business Economics of the Department of Commerce is uses. Traditional input-output analysis assumes that the economy is in equilibrium. Because this study was intended to investigate the broad fiscal effects of an attack, it modified the traditional input-output analysis to include relations generating final demand under conditions of economic disequilibrium. Consequently, supplementary relations connect government expenditure levels, private capital formation, and personal consumption expenditures with price levels, wages, savings, and other variables relating to value added. These have been taken from economic theory and econometric analysis

of historical data. The supplementary relations include those among unemployment, wage movements and prices; among interest rates, available funds and the allocation of investment funds among sectors; and among tax revenues, property values, activity levels, and income levels.

This model appears to be a step in the right direction because it includes many of the essential factors for studying post-attack recovery that are left out of most analyses. However, the data used are quite old, and the disaggregation of the economy into only nine sectors leads to simplifications that probably unwarranted. The true test of the utility and validity of such a model must rest on its application to crisis situations and tests of the sensitivity of the results to variations in the inputs. Although both of these are discussed in the report, no results are given, so there is no way to judge the value of the model. Nevertheless, this report is of interest because it is an attempt to simplify the economic analysis enough so that the total problem can be dealt with, rather than dealing with a small part of the problem in much more detail.

F. W. Dresch and S. Baum, Analysis of the U.S. and U.S.S.R. Potential for Economic Recovery Following a Nuclear Attack, Stanford Research Institute, SSC-TN-8974-85, January 1973.

The purpose of this study was to develop a practical method for translating estimates of possible damage from nuclear attacks into statements about recovery potenetial. The general approach involved use of a damage prediction model to provide the basis for estimates of the surviving capacity potential of each sector of the economy, and the capacity data were then used as inputs to an economic growth model having a matching number of sectors. As used, the economic model was always a highly aggregated one, having 7, 15, or 16 sectors.

The initial post-attack capacity constraint in each sector was taken to be a Cobb-Douglas function of the surviving capital facilities and labor force in that sector. Geographic detail was ignored in the recuperation model, however, and such considerations as transportation bottlenecks, isolation of surviving population and plant capacity cannot be taken into account in the model.

A linear program was then used to maximize the present value of GNP (or, optionally, NNP or Private and Governmental Consumption), subject to the stipulation, as functions of time, of minimum levels of private and governmental consumption, and of course, subject to initial sector capacity constraints. The imbalancing attacks treated, whether on petroleum refining or basic metals, failed to preclude rapid recuperation of the economy. It is tempting to allow oneself to be carried away by an analysis such as this to begin to believe that the findings have predictive value. But if they do, it is only in a very limited sense. The authors mention a principal reason why, though only in passing. The rapidity of the recovery of an economy thus modeled --

even whether it is to recover at all -- is very much dependent on the number of sectors that the analyst chooses to treat. If the economy is modeled as containing only a very few sectors, recovery tends to come easily since within a sector, free substitutability is implicity assumed. But if the economy is viewed as subdivided into many sectors, the opportunities for substitution are relatively minimal and recovery will, therefore, be impeded at every turn by bottlenecks. The supposed rate of recovery must, therefore, be recognized as dependent upon a modeler's choice: how many sectors into which to subdivide the economy for his purposes. It will also depend upon where the sector boundaries are put. This is not to argue that the authors of the document under review have worked with too few sectors (although they may have), but only that we don't know how to strike a proper balance between allowing for unrealistically large and unrealistically small amounts of substitutability.

There are other, better known problems with input-output analysis, particulary on the data side, but also relating to the distinction between what may be feasible from a purely technological standpoint, on the one hand, and from an organizational standpoint on the other.

An appropriate conclusion, then, is perhaps something like this: recuperation models having at their hearts input-output tables are indeed alluring constructions for tracing out the comparative effects of damage to alternative sets of targets. The findings obtained by their use may even be correct, but there are ample reasons to believe that such models are quite fallible. The results gained by applying far less sophisticated techniques may have as much chance of being valid. It is to be hoped that they, too, will continue to be used.

F. W. Dresch and H. B. Ellis, Criteria for Early Post-Attack Economic Viability of Local Areas, Stanford Research Institute, June 1974.

This report considers a wide variety of factors that could affect the early post-attack economic viability of local areas. The scope is narrowly confined to only those factors which would differ from one local area to another. Factors which would influence the viability of all local areas are not included in this analysis. This report is also limited strictly to economic factors. No consideration is given to the information and communication problem which would undoubtedly affect the viability of local areas; the author is obviously aware of such problems since his report, "Information Needs for Post-Attack Recovery Management," reviewed elsewhere, describes the information problems very well.

Factors are identifed in this report that could degrade local output, and time-dependent functions are proposed to reflect the degradation of output that could be anticipated as arising from each individual factor. The report represents this degradation of output from each local area (SMSA) by applying a time-dependent degradation factor to potential surviving capacity which drops to a minimum then rises monotonically approaching no degradation asymptotically.

Factors are discussed which affect local economic viability and degrade local productivity by adversely affecting either the local supply and productivity of labor or the utilization of capacity and productivity of surviving plant and equipment. Also, factors such as radiation and structural hazard are considered which can deny access to all or some portions of a local area. The various factors identified are classified into three categories according to their relation to area access, to labor

application, and to capital application. The dominant factors affecting local degradation are likely to be related to capital application because their direct and inescapable effects on output cannot be remedied quickly or significantly by local actions alone. Moreover, factors relating to labor application are significant only in areas experiencing labor shortages since losses of labor productivity can be compensated for by employment of additional labor insofar as it may be available.

The primary factors relating to capital application are those that at least temporarily restrict the flow of raw materials, energy, or other production inputs that come from outside the local area. Some of these can arise from bottleneck problems nationwide in critical industries, so they are not treated in this analysis.

Major factors affecting local economic viability or degrading potential output appear to be local transportation disruptions seriously interfering with the flow of supplies needed to operate local industry and to sustain the local survivors.

The study appears to have been done to assist in simulating national economic recovery in computerized recovery planning exercises. The methods in this report are proposed as an improvement upon the methods usually used in such exercises where a time is determined at which rehabilitation efforts could restore a nonviable to a viable status. The output of that area is considered zero until viability is restored and is considered undegraded afterwards.

The mathematical representations of degration purposed in this report appear to have the proper "shape" and are simple enough that they can be easily used for fast computer analysis, but conceptually they leave much to be desired. There is no justification for the choice of these mathematical functions except

that they have the correct shape and behave properly asymptotically. It would be more convincing if their derivation were based upon some physical logic rather than mathematical convenience.

F. W. Dresch and H. B. Ellis, Institutional Factors in Total Vulnerability, Stanford Research Institute, April 1968.

This report studies the following organizational problems relating either to the economic system or the political system.

- Solvency of individuals and business entities.
- Mobility of money and credit.
- Business management succession and corporate organization
- Vulnerability of normal business channels.
- Legislative imbalances at federal, state and local levels.
- Vulnerability of normal election machinery.

The findings indicate that none of these problems pose insurmountable difficulties, but do require prompt attention and appropriate or equitable resolution within the first few months after an attack. The study concludes that the principal threat to national viability appears to be the possiblity of mismanagement of early rehabilitation and recovery efforts. The observation is made that uncertainties in predicting the technical efficiency of the economy might look small compared with the even greater uncertainties in assessing possible degradation of productivity caused by failure of management.

The results in this report are not very sensitive to attack parameters. Only very large differences in attack parameters would be significant. Those attack parameters which would have the greatest impact are:

- Whether the enemy would launch a pure counterforce attack or an all-out attack on centers of population and industry.

- Whether there would be an allocation of weapons to petroleum refineries and vital transportation nodes (primarily marshalling yards) of sufficient numbers to immoblize the country for a protracted period.

- Whether appreciable strategic or tactical warning would be provided and acted on.

- Whether there would be any effective active or passive defense.

Effective defenses made possible by pre-attack preparations and appropriate response to early warning could greatly reduce the effects of a heavy attack and minimize the magnitude of many problems identified in this report.

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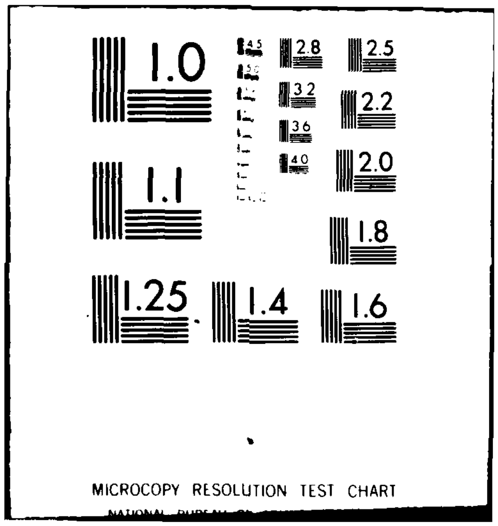
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MICROCOPY RESOLUTION TEST CHART

R. C. Dullien, E. A. Hudson and D. W. Jorgenson, The DRI Long-Term Inter-Industry Transactions Model, Data Resources, Inc., March 1977.

The DRI Long-Term Inter-Industry Transactions Model has been created from the Hudson-Jorgenson Macro-Economic and Inter-Industry Models for the United States' economy. These models have been integrated in a way that allows the rapid inclusion of further sub-models as well as the efficient use of the system for policy analysis purposes. The model described in this report is heavily energy-oriented, but a model more suitable for post-attack recovery analysis is being developed under FPA sponsorship.

The approach used in this report has great appeal because of its simplicity and flexibility. The macro-economic model provides the general characteristics of the economic environment. It consists of behavioral equations for the total economy. The parameters used in the model are derived from the 1947-1975 time period. A major problem with using the model for post-attack recovery would be the derivation of suitable parameters for the post-attack period. The inter-industry model disaggreates the macro-economic model's projections to a level which is more informative, yet manageable. Since the model described in this report is designed to study energy problems, the economy is divided into ten sectors, six of which are energy-related. These ten sectors are:

- Agriculture and mining.
- Manufacturing, excluding petroleum refining.
- Transportation.
- Communication, trade and services.
- Coal.
- Crude petroleum.

- Crude natural gas.
- Refined petroleum and substitutes.
- Electricity.
- Refined natural gas and substitutes.

For our purposes, the six energy-related sectors can be combined, leaving five sectors in the model. This, therefore, is about the simplest model that could be useful for our purposes. Thus, it would make sense for us to start out with this model and add sectors as the need for them is determined.

The model is designed so that the production functions can be determined by the macro-economic model or by the inter-industry model. This allows one to let the total economy function in a normal manner using the first mode of operation, or to control a portion of the production pattern through policies or assumptions relating to one or more sectors of the inter-industry model.

This model is a growth model. rather than a steady-state model, using a translog representation of the Cobb-Douglas production function. As such, the model includes labor as an endogenous variable. However, the supply of labor and the percent of labor unemployed are exogenous. It is possible, nevertheless, to make these endogenous by adding equations to the already existing system.

It has the advantage that the macro-economic model is integrated with an inter-industry model, even though the number of sectors in the inter-industry model is small. As with all macro-economic models, the major problem is the determination of coefficients which are suitable for post-attack recovery.

Federal Emergency Management Agency, Guidance on Priority Use of Resources in the Immediate Post-Attack Period (DMO-4), Draft of Part 104 of Chapter I of Title 32A - National Defense, Appendix, February 1979. (Originally numbered DMO 8500.1A when issued in 1964, and previously updated as DMP-4 in February 1975.)

This revision of the earlier Defense Mobilization Order provides for updating the survival items list to reflect changes in technology and laws. Areas especially updated include health supplies and equipment and veterinary medicine. The general policy is directed toward the objective of national survival and recovery. In order to achieve this objective, post-attack resources are to be assigned to maintain and save lives, to support immediate military defense and retaliatory operations, and to economic activities essential to continued survival and recovery. When the relevant Federal agency is able to function, it will be responsible for the use of resources under its jurisdiction. When not able to function, State and Local governments will be responsible for resource use.

Appendix I lists "items considered essential to sustain life at a productive level to assure national survival in an emergency." The items are arranged into seven major groups including:

(1) Health Supplies and Equipment;
(2) Food;
(3) Body Protection and Household Operations;
(4) Electric Power and Fuels;
(5) Sanitation and Water Supply;
(6) Emergency Housing and Construction Materials and Equipment; and
(7) General Use Items.

Very detailed lists are given for health supplies and equipment and veterinary medical items.

This list is of limited utility for several reasons. First, no quantities are provided. Second, the relations among complementary items are not expressed. Also, geographic differences are not addressed.

Jay W. Forrester, "Changing Economic Patterns," Technology Review, August-September 1978, pp. 47-53.

In this article, Forrester discusses the System Dynamics National Model constructed during the preceding six years and its use to understand patterns of economic behavior. The model contains 15 industrial sectors such as consumer durables, capital equipment, energy, agriculture and building construction. Each industrial sector of the model is built to represent a typical business firm in its sector of the economy. Sectors are connected through flows of people, information, money, prices and goods.

In regard to testing and validation of the System Dynamics National Model, Forrester writes: "Such a model is designed to be a role-playing replica of the real economy. It should behave like the real economy, generating the growth, fluctuations, shifts in population between sectors, inflation, unemployment, and other phenomena in the real world. Tested by the criteria of exhibiting behavior like that of the actual economy, the National Model is making solid contact with economic reality. The Model demonstrates its realism by generating the same kinds of behavior that are so puzzling in the national economy. For example, the Model exhibits the three major fluctuating modes of behavior that have been recognized and discussed in the economic literature--three-to-seven-year business cycles, intermediate term (15 to 25 years) investment (or Kuznets) cycles and long-wave or Kondratieff cycles spanning some 45 to 60 years. One of his conclusions from experiments with the model is that the "business-cycle behavior arises primarily from management of inventories, backlogs, and employment."

The complexity and development time of the National Model are far greater than Forrester's World Dynamics model which had five major level variables and was developed in a period of weeks rather than in years. Testing the National Model by comparing its behavior to that of the actual economy strengthens its claim to an empirical basis.

In contrast to his expressed confidence in his World Model for policy analysis and recommendations, Forrester is somewhat more cautious in appraising the policy impacts of the National Model: "The System Dynamics National Model is a step toward better understanding of socio-economic systems. The Model has now reached a stage at which it can begin to show the reasons for previously puzzling economic behavior. Experiments can now be conducted in search of more effective corporate and national policies."

Forrester, Jay W., Industrial Dynamics, MIT Press, Cambridge, Massachusetts, 1961.

Industrial Dynamics is a pioneering work published in 1961, based on efforts carried out by Forrester since 1956. Although the methodology was termed Industrial Dynamics here, broadened applications later led to revision of the name to System Dynamics. This book provides a definition, introduction, and profusely illustrated tutorial (e.g., a production-distribution system and a producer-employment system) on a modeling methodology and philosophy for "studying the behavior of industrial systems to show how policies, decisions, structure and delays are interrelated to influence growth and stability." The approach involves building models of companies and industries to assess how information and policy affect the organization.

The Industrial Dynamics methodology is a form of large-scale system simulation that allows many unique features to aid in representation of large complex systems. Among the most significant of these features are provisions for:

information feedback and control within the system,

management policies,

time delays,

exogenous variables, and

graphical output.

This last feature greatly facilitates communication of the method's results to a wide variety of people.

In the first chapter of this book, Forrester described previous Management Science efforts as predominantly exercises in formal logic of little use to top management. This and other

statements in the book established a gap between System Dynamics and Management Science that has remained wide. Some measure of current acceptance of the value of System Dynamics by management scientists is indicated by publication of Sexton's System Dynamics study of urban growth in the January 1979 issue of Management Science. However, the reverse, acceptance of some benefits of Management Science by Systems Dynamics is not evident even in the most recent works.

Another long and bitter battle has raged between System Dynamics proponents and economists who have preferred input/output analysis and econometrics for their large-scale models. For further details on this rivalry, see the bibliographic entry for Greenberger, Crenson and Crissey's Models in the Policy Process.

Forrester, Jay W., Urban Dynamics, MIT Press, Cambridge, Massachusetts, 1969.

Urban Dynamics, published in 1968, was written by Forrester when his work in Industrial Dynamics converged with that of Boston's former mayor (1960-1967), John Collins, to "focus attention of the academic community on the troubles of our cities." Collins and several others whom he brought into seminars formed the basis for Forrester's Urban Dynamics Model.

This book describes the results from this large-scale system simulation model and "their implications for urban programs." The key building blocks of the model were housing, labor, business and industry, with several categories for each. For example, housing was divided into slum housing, worker housing, and premium housing.

In 1968, urban programs were much in the news, and this book received considerable attention and criticism. Forrester's conclusions led to considerable criticism. In his final chapter he concluded:

> The city, by influencing the type and availability of housing, can delay an increase in the immigration rate until internal balance is reestablished. The city must press for removal of aging housing before deterioration creates an imbalance in the urban system. Because aging is continuous, the renewal process should be continuous instead of occurring in waves several decades apart. At the same time industrial parks should be established within present decayed residential areas to generate jobs for those already living in the city. (Emphasis added.) Favorable city regulations and new tax policies should be designed to attract the kinds of industry most needed for revival. The ensemble of new policies would be aimed at restraining the processes of urban stagnation.

The proposed new policies of urban management do not imply additional hardships on present urban residents except for relocation within the area. Relocation will be caused by three streams of change:

1. Slum demolition for gradually consolidating land into parcels large enough for the needed industrial centers (and any associated landscaping, parks, etc.).

2. Voluntary relocation from underemployed housing to worker housing as upward economic mobility makes such improvements in living conditions possible.

3. Economic relocation arising from revival activity as older housing is replaced by new housing and declining industry by new enterprise.

The critics simplified Forrester's conclusions to: remove slum housing, replace it with new industry, and don't worry about where the former slum residents go. He was also criticized for not including the suburbs in his model and for using only limited sources, viz. Collins and his associates, in the development of his urban model.

Jay W. Forrester, World Dynamics, Wright-Allen Press, Cambridge, Massachusetts, 1971.

World Dynamics was written in the extremely short period following Forrester's June 29, 1970, meeting with the Club of Rome and ending with the preface written in March 1971. Using five level variables as cornerstones of the model--population, capital investment, natural resources, fraction of capital devoted to agriculture, and pollution--Forrester looks at the world system and its problems of excessive population, rising pollution and disparity in standards of living. He "examines some of the forces that will become barriers when growth goes too far" and plots results from 1900 to 2100 AD.

The limits to world growth shown in graphical output from Forrester's model include: natural resource depletion, pollution crisis, crowding, and food shortage. He explores alternative means of dealing with these four limits and finds that when one limit is handled (say crowding via birth control) another is aggravated (say pollution). The author does not offer any easy answers for the four limits he pointed out.

World Dynamics and the subsequently published The Limits to Growth by Meadows, et al, created far more controversy than did Urban Dynamics. Two factors that gave ammunition to the critics were Forrester's claim that his World model illuminated actions that ran counter to intuition and his expression of greater confidence in the model for recommending policy. Two quotes illustrate these views:

> Having defined with care the model contained herein, and having examined its dynamic behavior and implications, I have greater confidence in this world system model than in others than I now have available. Therefore, this is the model I should use for recommending actions. (p. ix)

All systems seem to have sensitive influence points through which the behavior of the system can be improved. As pointed out earlier, however, these influence points are usually not in the locations where most people expect then to be. Furthermore, when a sensitive influence is identified, the chances are that a person guided only by intuition and judgement will alter the control variable in the wrong direction. (p. 113)

Jay W. Forrester and Peter M. Senge, Tests for Building Confidence In System Dynamics Models, Report D-2926-3, System Dynamics Group, Sloan School of Management, Massachusetts Institute of Technology, Cambridge, Massachusetts, December 1978.

This paper covers tests for building confidence in system dynamics models. It also discusses the difference between testing and validation of system dynamics models. The paper also briefly considers "statistical tests and measures of fit commonly found in econometric model-building." Overall this paper illuminates the differences in testing between system dynamics and econometric models.

Tests for system dynamics models fall into three groups: tests of model structure, tests of model behavior and tests of the policy implications of the model. Tests of structure determine confidence in model structure by comparing behavior that the model structure generates with behavior of the real system. Tests of policy implications determine confidence in a model's usefulness for policy design by applying the model to present and past policy issues and by assessing the robustness of a model's policy recommendations.

Tests of model structure without going into its behavior, include structure verification, parameter verification, extreme conditions, boundary adequacy (structure), and dimensional consistency.

Tests of model behavior include behavior reporduction, behavior prediction, behavior anomaly, family member, surprise behavior, extreme policy, boundary-adequacy (behavior), and behavior sensitivity.

Tests of policy implications include system improvement, changed-behavior prediction, boundary adequacy (policy), and policy sensitivity.

Their definition of testing involves "the comparison of a model to empirical reality for the purpose of corroborating or refuting the model." They describe validation as the process of establishing confidence in the soundness and usefulness of a model, with "the ultimate objective of validation is transferred confidence in a model's usefulness as a basis for policy change" (p. 5). Successful model testing can be seen as leading to model validation.

In a brief section on statistical testing Forrester and Senge take issue with statistical tests such as t-tests because "low t-statistics frequently result from errors in measuring the data or from 'collinearity' of data over the period during which the measurements were made." They find a more promising approach to statistical testing in system dynamics models using the Kalman filter developed in engineering.

> Statistical tests based on the Kalman filter differ from conventional econometric tests as behavior tests differ from structure tests. Conventional statistical tests attempt to statistically compare model structure directly to data; Kalman filter tests compare model behavior to data. The difference in approach permits tests based on the Kalman filter to separate out the effects of measurement error when testing hypotheses and may prove significant for applications in system dynamics. (p. 27)

In research of common ground for testing of system dynamics and economics models, one can at least point to comparing model performance to empirical reality for both types of models. Unfortunately, they still remain far apart on statistical testing.

R. D. Gastil, Scenario for Post-Attack Social Reorganization, The Hudson Institute, HI-1188-RR, August 1969.

This report develops a very believable scenario covering the events leading up to a nuclear exchange between the U.S. and the Soviet Union and the efforts to return to normalcy afterwards. The scenario covers a period a little longer than two years set in the time frame from 1970 to 1972. The attack used was OCD's CIV-LOG attack developed for a war about 1965 in which 2000 megatons were used. Although the attack was primarily against strategic forces, there was a great deal of urban damage caused either intentionally or as a secondary effect. Fatalities were about 15 percent.

The purpose of the scenario is to provide insight into potential problems -- especially insight into problems that are amenable to pre-attack plans and preparations. This scenario does an exceptionally good job of exactly that. To be realistic, any model of post-attack recovery should include a large number of the problems illustrated by this scenario. Although it would be impractical to build a model which includes these problems specifically, the inefficiencies and delays that they introduce can be, and should be, included in a model in economic recovery.

The following points relating to post-attack recovery appear to emerge from this scenario: neither disorientation nor social breakdown would occur to the extent that it would threaten recovery. The scale of destruction and its implications are likely to be a great deal more serious in terms of casualties, industrial destruction, loss of housing, and area isolation than nuclear destruction models based on blast, fallout and immediate thermal damage would lead us to assume. Large-scale geographical isolation may occur; California, in particular, is likely to be

isolated and fragmented for some time. It is most likely there will be continuing important defense needs and overseas obligations after a nuclear attack. The only case in which this would not be so would be defeat, and defeat would raise the most serious problems for recovery, both materially and morally. The most relevant governmental units for post-attack survival and reconstruction will probably be the states, not the federal government. One of the primary govermental problems in the post-attack situation will be that of persuading relatively well-off states and communities to help more completely helpless peoples and areas. In the month following the attack there will probably be critical food shortages in local areas. Finally, with minimum attention to economic principles, inflation should not be a serious problem.

The strongest overall impression this reviewer obtained from this scenario is that recovery is very likely to be a local, not a national, endeavor. The differences between different regions are likely to be so striking that any model of recovery which attempts to treat them by dealing with national averages is likely to ignore the very essence of the recovery needs of the different regions. It is possible that a more devastating attack which kills a much larger fraction of the population and causes considerably greater damage to the economy might be such that recovery from it could be modeled on a national scale, but it is likely that a larger disaster would only exacerbate the regional differences shown in this scenario.

William G. Gay and William W. Chenault, Crisis Relocation: Distributing Relocated Populations and Maintaining Organizational Viability, Human Sciences Research Report, HSR-RR-74/2-Se, April 1974.

This report studies alternative methods for assessing hosting capacities for communities during crisis relocation. Indicators considered include:

- fallout
- basement spaces available
- per capita retail trade
- housing quality
- poverty levels

The study concludes that hosting capacity should be based on the capacity of communities to support additional population and to organize and utilize (i.e., employ) relocated workers. The report underlines the need for maintaining organizational continuity and affiliation of government, production and service workers through a crisis involving relocation. The test case used was Richmond-Petersburg, Virginia and 17 surrounding counties.

The overall conclusion is that relocation cannot be separated from the question of organization in the host area during the crisis period. Contingency plans should provide for a wide range of situations.

Viability requirements include:

- Ecological requirements (housing, food and mdeical services and facilities.
- System distribution requirements (retail trade, transportation and utilities, construction, public employment and wholesale establishments).
- National economic systems requirements (manufacturing, tobacco (!), chemicals and lumber).

Richard L. Goen, The Magnitude of Initial Post-Attack Recovery Activities, Stanford Research Institute, Project EGU-7959, Final Report, December 1971.

The report analyzes the life support tasks of the initial post-attach recovery period from the time survivors emerge from shelters until they have been provided with adequate accomodations.

The major tasks for survival analyzed are:

- debris clearance
- delivery of food and water
- decontamination
- relocation of homeless survivors
- boarding windows

Scenarios used are a severely damaged SMSA and a lightly damaged SMSA. Measures of effectiveness used were man-hours of effort, number of men, and amount of equipment required. No consideration of fuel needs, fuel shortages or any transportation problems was given. This report contained many details and numbers.

Richard L. Goen, Richard B. Bothun and Frank E. Walker, Potential Vulnerabilities Affecting National Survival, Stanford Research Institute, September 1970.

This report assesses the damage of an 800 weapon attack (500 MT) on the United States. Damage is assessed to manufacturing, petroleum pipelines, electric power production, and housing. The authors concluded that:

- "Significant compensation for losses in generation and transmission capacity losses can be accomplished by effective post-attack management in power consumption." By this is meant rationing, elimination of non-essential users and staggering peak demand hours.
- The pipeline system is very vulnerable if attacked but a substantial capability would exist for substituting rail and truck transportation of petroleum products for pipelines. The authors calculated that pipeline deliveries could be met using 57 percent of the tank trucks with over 2,000 gallons capacity.
- "The residual capacity outside the large metropolitian areas in several important manfacturing sectors is extremely vulnerable if specifically attacked."
- 800 weapons with about 500 MT total yield could eliminate all but a few percent of capacity in several important manfacturing sectors simultaneously.

34 industrial sectors and 71 of the largest SMSA's were considered.

Leon Gouré, Shelters in Soviet War Survival Studies, Advanced Studies Institute, 1978.

This work details Soviet blast and fallout shelter status, plans and trends. In the 1960's, the Soviet civil defense first priority was pre-attack evacuation while in the 1970's, shelters have primary emphasis with the stated goal of having the capability to "shelter the entire population in protective structures," in the event of insufficient time to carry our or complete the evacuation. Shelters may or may not be designed for dual-purpose use such as garages, classrooms, subways and tunnels in mines, etc. Included were super-hard shelters for elite and command and control. Filtering systems, space, air and water supply considerations were detailed. The estimated annual investment in shelters was given as two billion rubles, based on a 20 year plan. Shelter construction is already well underway. This shelter capacity will:

- protect population in sudden outbreak of war
- avoid giving West notice of war which evacuation would provide.

Leon Gouré, Soviet Civil Defense - Post-Strike Repair and Restoration, Center for International Studies, University of Miami, Final Report for DCPA, Contract No. DAH C20-70-C-0309, June 1973.

This report describes and analyzes (using open Soviet source material) Soviet civil defense doctrine, organization plans and activities pertinent to post-strike emergency repair and restoration operations. The author notes "that Soviet doctrine emphasizes measure to assure the viability of essential industrial facilities, utilities, services and transportation in wartime as vital to the war effort and for the attainment of victory." Damaging limiting measures include:

- industrial dispersal
- simple hardening
- stockpiling
- preparation of large civil defense forces to conduct rescue, repair and restoration in damaged areas

Although much has been accomplished, deficiencies persist (as of 1973) in their civil defense programs.

Leon Gouré, War Survival in Soviet Strategy - U.S.S.R. Civil Defense, Center for International Studies, University of Miami, 1976.

Foy Kohler states in the forward (p. xii) that:

> The Soviet program represents a comprehensive "package" wherein population survival measures are combined with a long-run program of the dispersal of key industries; underground and otherwise hardened industrial sites; hardened facilities for protecting the political leadership and its nationwide command and control structure; and hardened facilities for communication and command and control for the armed forces.

This represents a two pronged strategy - the destruction capability of the U.S. and the survival capability of the U.S.S.R. are assured.

This monograph gives rationale for the Soviet civil defense and detailed plans for training, evacuation and shelter organization.

Four conclusions in Gouré's book are seen by Kohler:

- Civil defense and other war survival measures are central to the U.S.S.R.'s strategic planning.
- The war survival program has been stepped up since 1972.
- Soviet leaders attach great importance to the U.S.S.R.'s superior position over the U.S. in war survival capability and especially regarding the concentration of population and vital economic resources.
- Soviet leaders believe that these asymmetries between the U.S. and the Soviet capabilities give them a distinct advantage with regard to risk taking and improved chances of winning.

M. Greenberger, M. A. Crenson and B. L. Crissey, Models in the Policy Process, Russell Sage Foundation, 1976.

This excellent book presents an interdisciplinary study of policy modeling for government reflecting the perspectives of economics, political science and management science. This book covers modeling as a process and as a form of policy research. Nine methodologies for policy modeling are reviewed briedfly with expanded chapters on two of the methodologies: system dynamics and econometrics. Several case studies based on the New York City-Rand Institute are described from the viewpoint of seeking insights regarding success or failure in use the modeling results. The final chapter explores the relation of modeling to the political process. The authors conclude: "When all is said and done, the way to make policy models more useful in policy is through greater understanding and generally improved communications between policy modelers and policy makers."

The chapters on econometrics (6) and system dynamics (5) highlight the long and bitter battle between proponents of these methodologies. The primary sources of the battle were Forrester's Urban Dynamics and World Dynamics. Both were condemned by economists for lack of empirical support and statistical validation. Perhaps oversimplifying, the adversary positions are not surprising given the structure-orientation of System Dynamics and the data-orientation of both econometric and input-output models.

W. A. Hamberg, Transportation Vulnerability Research: Review and Appraisal 1959-1969, Stanford Research Institute, January 1969.

This report reviews studies concerned with the vulnerability of the U.S. transportation system and with relating that vulnerability to the system's post-attack surviving capability to perform. The lack of a clear understanding of the post-attack society's recovery goals and schedules precluded meaningfully relating the capability of the surviving transportation systems to meet post-attack demands.

An extensive literature search was conducted and yielded an annotated bibliography contained in the report's appendix. This report concluded that despite the vast number of documents on transportation vulnerability, there have been virtually no developments to help solve the transportation data problems nor to improve the methodology for analyzing large national transportation systems and their sub-sectors.

The usefulness of the results contained in this report is impaired by two assumptions. The first is that the attacks studied were not designed to attack the transportation system. The second is that the survivors would be motivated to return to work when and where needed and there would be other conditions present that would facilitate the orderly resumption of economic activities.

W. A. Hamberg and R. W. Hall, _Vulnerability and Surviving Capability of the Nation's Transportation Systems, Interim Report: Development and Test of Methodology_, Stanford Research Institute, March 1970.

Although a methodology is needed to analyze transportation capabilities that is more detailed than input/output analysis, the methodology described in this report does not fill that need due to the detailed data and extensive analysis required to build the model.

The methodology is directed to determining the capability of a multi-mode transportation system to move a given amount of goods and people according to a required schedule and distribution pattern.

Robert A. Harker and Charlie C. Coleman, Application of Simulation Training Exercises to Crisis Relocation Planning, Center for Planning and Research, December 1975.

This report describes six workshop exercises, three for nuclear confrontation and three for earthquake prediction, held with San Francisco Bay area local governments. The objective of the research effort was to assist DCPA in incorporating relocation planning guidance materials and computerized scenario capabilities (dial-a-scenario) into its on-site assistance program. This report describes the development of the simulation exercise, its applications, and the impact of workshop results for the ALFA and BRAVO NADOP and NEOP relocation planning guides. Among the overall conclusions, it is not surprising to see:

- "Local governments need to plan for both in-place and relocation protection options during the pre-crisis and crisis time buildup frames.
- Crisis relocation planning requires integrated efforts among local jurisdictions and among different levels of government."

Nor is it stunning to see that

- "There is a strong disinclination among exercise participants to read materials. On the other hand, the same data are readily accepted."

The final recommendation was for a program of exploratory workshop exercises using the advanced planning materials and the prototype relocation guidance.

Appendices include Analyses of Planning Guides for Alert and Warning Events, Nuclear Confrontation and Earthquake Prediction Scenarios, and Participants' Responses.

Robert N. Hendry and Dora B. Wilkerson, A Model of the Local Civil Defense Operating System, Research Triangle Institute, March 1972.

This report describes the continued prototype design of their time-phased Local Countermeasures Model for assisting local civil defense operations following an attack. The objective of this effort is to assist in valuing alternative countermeasures. Problems to be addressed by the model include:

- Damage Control Problems
- Readiness Problems
- Relief and Rehabilitation.

Solutions involve resource assignment and deployment.

This paper reflected preliminary work on a model that appears not to have been developed further.

J. Hirshleifer, Disaster and Recovery: A Historical Survey, The Rand Corporation, RM-3079-PR, April 1963.

This report does not present any models of recovery, but it provides some insight into the process of recovery and provides some examples of recovery after disasters which might be useful in testing any model that is developed.

The majority of this report studies four generalized disasters: Russia under War Communism after World War I, the American Confederacy, Germany during and after World War II, and Japan during and after World War II. The main questions examined are:

1. What is the mechanism whereby external or internal stress brings on economic breakdown?
2. To what degree was the source of collapse, in the instances surveyed, technological (in the form of physical reduction in production possibilities) and to what degree organizational (caused by policy errors)?
3. What were the main forces promoting or hindering recovery from disaster?

The experiences reviewed all displayed one or another variant of what seems to be a characteristic organizational phenomena in disaster -- the breakdown of the money-food trade between cities and countryside. The generalized disaster phenomena may culminate in a number of ways. First, economic collapse may occur. Alternatively, there may be an easement of the external source of stress before economic collapse takes place. With such a remission, recovery generally becomes possible.

The report concludes with a conjecture that the speed and success of recovery in the observed historical instances have been due in large part to the proportionately smaller destruction of

population than of material resources. That the proportionate survival of of population may be the critical factor is suggested also by the fact that completely depopulated cities have often failed to regain to their former size and prosperity, in comparison with cities largely destroyed physically, but where substantial fractions of population survived. Hirshleifer states that an argument for this conjecture could be based upon the prepositions that: (1) the fraction of the community's real wealth represented by visible material capital is small relative to the fraction represented by the accumulated knowledge and talents of the population, and (2) there are enormous reserves of energy and effort in the population not drawn upon in ordinary times, but which can be utilized under special circumstances such as those prevailing in the aftermath of disaster.

A final, somewhat related conjecture, is that economic recovery seems possible over an extremely wide range of damage.

Francis P. Hoeber, "Civil Emergency Preparedness if Deterrence Fails," Comparative Strategy, Vol. 2, No. 3 (1979).

This paper argues for civil emergency preparedness (in general, no specifics are given) in two stages. The first stage of the argument is the failure of deterrence is likely to be by degrees rather than with a "big bang." The second stage of the argument is that well-planned civil emergency preparedness could promise some damage limitation plus contribute to the deterrence of diplomatic coercion before deterrence fails.

Francis P. Hoeber, "How Little is Enough?," International Security, 1979

This article addresses the question "How low can U.S. and Soviet nuclear arsenals go and still permit the retention of a stable power balance?" as well as other questions related to the risks and rewards of bilateral force reductions. The author concludes that bilateral force reductions up to one-third or one-half may be useful if they are equitable and veriable, but further reductions would lessen U.S. security. The reasons given for this lessening of security are increased ease of destabilization and a weakening of alliance cohesion due to the shrinking U.S. umbrella.

Civil defense is seen as an integral part of the strategic military posture, not as a purely civilian matter. Further, Hoeber states that the U.S. cannot continue to ignore the growing U.S.-Soviet asymmetry in civil defense. He broadly defines civil defense to include a wide range of preparedness measures including protection of the population, industry and continuity of government. The last mentioned covers protection of leadership, communications and information bases, and arrangement for post-attack federal-state-local cooperation.

Michael D. Intriligator, Strategy in a Missile War: Targets and Rates of Fire, Security Studies Project Report No. 10, University of California, Los Angeles, 1967.

This report analyzes missile strategy when both targets (counter force and counter value) and rates of fire can vary over time during the war. A dynamic model of differential equations is constructed and is solved by optimal control theory. Some of the results include:

- variations in missile strategy can only delay, but not avoid casualties;
- missile hardening promotes a zero rate of fire for the enemy but also concentrates enemy fire on cities;
- civil defense appears to be the best means to limit the casualties since it promoted both a zero rate of fire and counterforce targeting for the enemy.

Thomas K. Jones, Industrial Survival and Recovery after Nuclear Attack, Boeing Aerospace Co., Report D180-20236-1, 1976.

This is a the detailed report which provided part of the back-up for Jones and Thompson's article in ORBIS. The report addresses two questions regarding civil defense:

- Can Soviet industry be effectively protected by the methods described in Soviet literature?
- Is it feasible to apply similar concepts to protect and ensure post-war recovery of U.S. industry?

The work done for this report led to affirmative answers to both questions. The report concludes "...it is believed that a civil defense program will permit the United States to maintain its security for less cost and with less nuclear weaponry that would otherwise be required."

An appendix contains follow-up questions based on the report and Boeing's answers.

T. K. Jones and W. Scott Thompson, "Central War and Civil Defense," ORBIS, 1978.

This article makes the case for increased civil defense via analysis of various 1985 SALT II scenarios including multiple strikes and alternative civil defense strategies with scales of recovery time ratio and strength ratio (equivalent weapons). It finds most cases favor the USSR on both recovery and strength ratio scales. It concludes that civil defense efforts should be increased to improve our post-attack prospects and our pre-attack negotiations.

Fred M. Kaplan, "Soviet Civil Defence: Some Myths in the Western Debate," Survival, Vol. 20, No. 3, May/June 1978.

Fred Kaplan is apparently not very impressed with Soviet civil defense and presents in this article an attack on eight points of views of those who are impressed with it (such as Leon Gouré and T. K. Jones). His principal thrust is that even though Soviet civil defense activities have been expanded, they are still not that effective.

For an example of one of the views of those impressed with Soviet civil defense and Kaplan's counter arguments, consider the following:

> The Soviet Union has an impressive evacuation plan incorporating most of her urban population. No major city in the Soviet Union has staged an evacuation exercise, nor have any smaller cities conducted a full-scale evacuation. Of those drills that have taken place, none has been executed simultaneously with any other; only one form of transportation has been used; the drills had been prepared weeks in advance. It would be an extremely demanding task to evacuate Moscow, Leningrad, Kiev and the other 219 Soviet cities with populations above 100,000 without a single rehearsal - and highly risky if it constituted a crucial aspect of a nuclear offensive (or threat of an offensive) that would itself be hazardous.
>
> Calculations based on figures in Soviet civil defence manuals, indicate that 1.1 to 1.6 million people would have to co-ordinate the evacuation and alerting of citizens, registering of evacuees, issuing travel authorizations to them, forming convoys, providing shelters, and keeping evacuation commissions apprised of the evacuation's progress. These organizers, according to the manuals, would be drafted "from the individuals not subject to call-up by the armed forces". How so many people would be selected, located, instructed and compelled, is not spelled out.

> Problems with transportation would be manifold. Most rail lines are single-track. Most of the trains are constantly loaded with freight, and many would not be in the right place at the right time. In a wartime emergency (which this certainly would be), many would be transporting reserves and equipment into Eastern Europe and along the Sino-Soviet border. There are only 4.2 million motor vehicles in working order in the Soviet Union. Roads are poor, only one-third of them being hard-surfaced. In winter, spring or autumn deep snow and ice or else heavy rainfall, would exacerbate the problems.
>
> Even optimistic sources assume that 20 percent of the urban population - or about 17 million people - would have to walk. In his calculations, T. K. Jones assumes that they walk 30 miles in one day and then construct expedient shelters. But this would be a remarkable speed, especially if weak, very young, or old people were involved and if shovels, food and other necessities were carried.
>
> In addition, since Moscow and Leningrad, for example, are surrounded by other industrial cities, whose residents would also be evacuating, and since Leningrad borders on to the ocean, evacuation of the Soviet Union's two largest cities would not disperse their populations to any great extent.

His argument presents a list of difficulties facing an evacuation of Soviet cities. However, there is no quantitative assessment of the degradation of the evacuation plan caused by the difficulties cited. What does he mean by the last phrase quoted above: "evacuation of the Soviet Union's two largest cities would not disperse their populations to any great extent"?

What is most revealing is the view of those impressed with Soviet civil defense that Kaplan has not chosen to argue, namely that Soviet civil defense preparations are substantially greater than U.S. civil defense.

Arthur Katz, Economic and Social Consequences of Nuclear Attacks on the United States, a study prepared for the Joint Committee on Defense Production, U.S. Congress, 1979.

This study reviews national effects of four postulated attacks and examines in greater detail the effects of such attacks on Massachusetts. It has a rather pessimistic view of recovery - not enough surplus to sustain rapid economic growth or recovery for five years or longer. Serious effects considered are economic, psychological, social and political. The study does not have a very hopeful view of the use of evacuation unless plans for long-term disruption of society are made.

The largest reference on the attack used is taken from "Potential Vulnerabilities Affecting National Survival" by Goen et al at Stanford Research Institute in 1970. The attack is directed at hampering economic recovery and uses 500 1-Megaton and 200 300-Megaton weapons.

The author points out that agricultural output will drop significantly due to the loss of petroleum products including both fuel and fertilizer since 98 percent of refining capacity is predicted to be lost. Also, severe loss of medical personnel and treatment facilities is predicted due to their concentration in large cities.

The author criticizes current relocation planning as inadequate to deal with the social and logistical difficulties with or without a war. He does not appear to take relocation into account in assessing attack damage.

His attack damage estimates are high (see, for example, PONAST II) and are based on several arguable assumptions.

M. Kennedy and D. E. Smallwood, A Recovery Model: Design and Initial Analysis, The Rand Corporation, WN-10099-DNA, January 1978.

This report presents preliminary results from a post-attack economic model being developed at Rand. The model is designed to provide a context for analyzing economic targeting issues. This report presents the general approach being used in the modeling effort and constructs a simple prototype version of the type of model that is being developed.

The basic model used in this report integrates an input-output structure with a now-classical production function which allows for the substitution of labor for capital. Since only four sectors are considered in the preliminary model -- consumption goods, industrial infrastructure, military support, and capital goods -- the model inherently allows for free substitution within any one of these sectors. It is planned in further development of the model to break the economy down into a larger number of sectors, thereby reducing the substitutability that is in the preliminary model.

The relationship between output and the inputs of capital and labor is different from the Cobb-Douglas function usually used in such models. The function used in this model is a constant elasticity of substitution production function. The relationship between maximum output, available capital and labor is given by

$$X^k = a[\alpha K^k + (1-\alpha)L^k]$$

where

$$X = \text{maximum output}$$

$$K = \text{available capital}$$

$$L = \text{labor}$$

$$k = 1 - \frac{1}{\sigma}$$

$$\sigma = \text{elasticity of substitution}$$

$$a, \alpha = \text{constants.}$$

As $\sigma$ ranges from zero to plus infinity, the entire range of possibilities, in terms of the substitutability of capital and labor are represented. The case $\sigma = 0$ represents no substitution. With $\sigma = +\infty$, the production becomes a linear relationship in which labor can be substituted for capital in a fixed ratio, no matter what proportions are used. For small positive values of $\sigma$, substitution possibilities are limited, and gradually become greater for higher values. The values of $\sigma$ used for the examples in the report range from 0.2 to 0.8. No justification for this choice is given except that it appears to be a reasonable range for such an example.

The normal econometric model of an economy contains dozens of equations describing the constraints on the economy. This model contains only the one between capital and labor. The only way to tell whether this single constraint is adequate would be to add other constraints and see how much they influence the results.

The report draws some "lessons" from the preliminary analysis about the advantage of different targeting schemes. It states that the relative effectiveness of bottleneck targeting is crucially affected by substitution possibilities and is far greater

on immediate possibilities than on long-range production possibilities. These results are obvious without any modeling, but it is comforting to note that the model does not give intuitively correct results in this instance. As with all models which predict growth, the analyst has to select the investment strategy. The approach used in this modeling effort tries to get around the analyst being a clairvoyant, by constructing relevant portions of the "possible production frontier" rather than saying what production will actually select. However, the points on this frontier are calculated using the assumption that consumption will remain constant over the period for which calculations are made. There is no way of knowing whether the frontier generated in these calculations is in any sense an optimal frontier since no criteria for optimality are proposed.

Richard Laurino, Frank Trinkl, Robert Berry, Ruth Shnider, and William MacDougall, Impacts of Crisis Relocation on U.S. Economic and Industrial Activity, Center for Planning and Research, Inc., 1978.

This study continues a DCPA project on determining the potential economic and industrial impacts of crisis relocation. The problems examined are:

- Payment mechanisms during the relocation period
- Activity levels in essential industries
- Economic impacts during and after crisis
- Application to a local test area

The costs of crisis relocation maintenance are estimated to be large: $25 billion (1975) to the private sector and $20-30 billion to the government. Economic disruption ends one to two years after crisis relocation (if not followed by attack).

The authors use their TEMCRIS II macroeconomic model to estimate the economic impact of crisis relocation. This model has 19 equations with 19 endogenous and 17 exogenous variables. The model is aggregated at the national level and it includes no sectoral detail on particular industries or products.

Since TEMCRIS II is essentially a demand model, a Linear Programming I/O model is linked to TEMCRIS II to provide a supply model as well. The LP I/O model has 85 industry sectors and 116 resources in use - 40 labor, 67 critical materials, 8 energy end-products, and 1 capital flow requirement.

Appendices include "Crisis Relocation Impact Factors on the Banking System" and "Methodology for the National and Colorado State Food Production Study."

With a focus on Finance, Food and Industrial Production, the effort described here may well be increasingly useful for assessing the impacts of crisis relocation without a nuclear attack. However, since the model described here lacks transportation, behavioral and management considerations, its usefulness for post-attack economic analysis is impaired.

Richard Laurino, Frank Trinkl, Carl F. Miller, and Robert A. Harker, Economic and Industrial Aspects of Crisis Relocation: An Overview, Defense Civil Preparedness Agency Report CPG 2-8-16, 1977.

This report divides crisis relocation (CR) into initiation, maintenance and reconsitution phases. It focuses on economic effects of CR on individual families, on businesses, on financial institutions, on industry and on state and local governments. It estimates impacts of CR up to the reconstitution phase to be on the order of tens of billions of dollars. It describes an econometric model for assessing impact of crisis relocation.

H. Lee, Industrial Recovery Modeling: Post-Attack Demands and Potentials, Stanford Research Institute, January 1970.

This report demonstrates the use of an industrial production model in generating the industrial network input demands for the production of 21 final consumer items considered important to post-attack survival and recovery. The list of 21 items is made up of commodities that are generally included under food, clothing, and shelter, and a few additional items that are basic to our mode of living and essential to post-attack recovery. The analysis of requirements is limited to four tiers. A tier is defined as follows: The first tier of requirements are those used directly to produce the final output, the second tier are those requirements needed to produce the requirements in the first tier, etc. With this definition, the total of network items in the combined networks for the 21 final consumer items is 248.

An earlier study looked at the single consumer item of bread and determined that 91 network items were needed in the bread production network when 3 tiers of processing facilities were considered. Thus, the expansion of the number of final consumer items from 1 to 21 only increased the date requirements by a factor of 3. (If the bread network had been considered to four tiers in processing facilities, it would have required 112 network items. Thus, the expansion to 21 items really only increased the data requirements by a factor of two.) This result can be interpreted to mean, as it is interpreted in the report, that a large number of final items could be analyzed without significantly increasing the number of network items for which data would be needed. A different interpretation would be that even a small number of final items depends on nearly the total number of network items; thus, when one considers a sufficient number of tiers, any one item depends on nearly everything else. The

issue, of course, is how significant is the dependence of a final item on any network item that may be in short supply? The approach used in this report will tell you the quantity of the network item that is required, but not its criticality. Thus, the results of this report are useful only in the case where there are no substitutions possible and since every final item depends on nearly all network items, that case would result in near paralysis of the economy.

Apart from the model presented in this report, the appendices to this report contain some useful data. Appendix A contains the direct production inputs per unit of output for over 200 items. Appendix B contains the summed network inputs for the production of a unit of quantity for each of the 21 final consumer outputs. These inputs were obtained by multiplying the production ratios given in Appendix A successively along each processing branch to a depth of four tiers. Unfortunately, Appendix A is incomplete since some input quantities to some processes were not known. As a result, the missing inputs were left out of Appendix B and, in addition, not all process branches were traced to a depth of four tiers.

It is recognized that a sophisticated, complete transportation system within the United States would necessarily be required for post-attack survival and recovery. As a result, this report outlines a simulation model of the transportation system which if implemented might be useful in determining the adequacy of post-attack transportation. Unfortunately, the complexity of such a model precludes its being included as part of the hybrid model proposed in this report. The report also acknowledges the importance of manpower, but as in the case of transportation, concludes that manpower cannot be included in hybrid models either.

The report concludes that it appears feasible to use the industrial model concept to expand input-output analysis for probing in selected areas below the level of aggregation imposed by available input-output tables. The results obtained by such an approach would not be a general-purpose economic model but rather a methodology for developing models of actual or contingent situation to a detail sufficient for diagnosis of even local and transitory bottleneck problems. A transportation model concept that is compatible with the industrial production model can be developed. Total implementation of the industrial production model was not recommended. It was recommended that a mixed model be developed that would incorporate the capability of the industrial production model to prove candidate industrial production areas in detail and the capacity of input-output analysis for organizing a picture of the whoe economy.

This reviewer concludes that this report demonstrates that it is possible to integrate industry models with input-output tables. That is, in principle, a hybrid model can be built. However, this reviewer also gets the impression that practical limitations would make such a model extremely limited in scope. But even if such a model were built, we have to ask: "When you are all through, what have you got?" The stated purpose in this report for integrating industry models with input-output models is to investigate the impact of bottlenecks in more detail. Nothing in this report indicates that the approach used in this report will give any insight into that problem. The results of this approach will tell us in more detail than an input-output model what inputs are associated with what outputs, but given that nearly all inputs are associated with almost any output, this reviewer fails to see where this information is useful. Without further information about substitutability, the results of the approach used in this report are interesting but not very useful. At best, it serves as a clue to where one should look for substitutability.

This report by itself appears to be an excellent piece of research. It is intended to be one piece in a large effort to build up a capability for post-attack analysis. Apparently, at the time the research was funded with the expectation that all the pieces would fit together and, upon completion, we would have an understanding of post-attack survival and recovery. Past experiences with such large bottom-up efforts have usually resulted in the effort being dropped before all the pieces were completed, so it would be difficult to say whether success would have been possible. This reviewer feels strongly that success in such cases never comes, even if funding is maintained until the bitter end. Even if the models that are developed would successfully represent the real situation that they are modeling, the data requirements and other maintenance requirements of the models result in their falling quickly into disuse. The longer they are not used, the more out of date they become, and the more difficult it is to get them running again. As a result, this reviewer finds little merit in pursuing the stated objectives of the research effort represented by this report.

One would like to think that by narrowing the problem down to a few critical items, the analysis could become tractable. But the results of this report strongly discourage such hope. This report shows that a large fraction of all possible inputs are used in any one output, even if one goes only four tiers deep. That result makes the prospect bleak for finding any practical results from even a highly focused analysis.

Robert Leggett, Panel Chairman, Civil Defense Review, Hearings by the Civil Defense Panel of the Subcommittee on Investigations of the Committee on Armed Services, February and March 1976.

Boeing's T. K. Jones (pp. 206-267) testifies of the effects of Soviet civil defense on U.S.-Soviet strategic balance. He concludes that it would keep their casualties to 3 to 4 percent of their population or about 10,000,000 people and that their civil defense is cost effective and that we should do the same.

Gouré (pp. 187-205) describes Soviet civil defense population protection measures including gas masks, protective clothing, shelters, fallout cover and urban pre-attack evacuation and dispersal.

According to Gouré in the Hebert hearings (p. 192), urban shelters are usually built for 100 to 300 people either in apartment building basements or which stand alone. They contain blast-proof doors (usually double), filter ventilation systems, air regeneration equipment, emergency exits, bunks, electric power, heat, water supply, telephones, radios, toilets, etc. They are hardened to 100 psi and radiation attenuation factor of up to 1000.

Note: The Moscow subway has blast doors and is estimated to be able to shelter one million people.

Jan M. Lodahl, "SALT II and American Security," Foreign Affairs, 1978/79.

The author assumes a pro-SALT attitude. He provides a summary of SALT I, SALT II, and thoughts for extension to SALT III. He analyzes both the U.S. and Soviet capabilities and trends. The article considers European defense problems as well as the U.S. He states that limits agreed to in SALT II (e.g., 3 year moratoria on deployment of MX and sea and land based cruise missiles) will not bind because we would not be able to deploy during this time frame. Also contained are some sparse thoughts (p. 254) vis-a-vis Civil Defense, He does not believe that Soviet Civil Defense is that effective (to limit casualties to 10 million).

Nathaniel J. Mass, Introduction to the Production Sector of the National Model, Report D-2737-1, System Dynamics Group, Sloan School of Management, Massachusetts Institute of Technology, Cambridge, Massachusetts, July 1977.

This paper provides an overview of the structure of the standard production sector of the System Dynamics National Model. This model was used as the basis for Forrester's paper "Changing Economic Patterns" in Techr ology Review in 1978 (also reviewed in this bibliography).

The standard production sector has a structure which is essentially that of a single firm in the economy. By adjusting parameters such as normal inventory coverages, delivery delays, and proportions of different factor inputs, the standard sector can be adapted to fit different sectors such as consumer goods, capital equipment, energy, agriculture, and transportation. There are 15 production sectors in the National Model, specifically,

1. Capital goods
2. Consumer durables
3. Consumer soft goods
4. Resources
5. Knowledge
6. Energy
7. Transportation
8. Residential construction
9. Commercial construction
10. Services
11. Agriculture
12. Food processing and distribution
13. Secondary manufacturing
14. Government services
15. Military and defense

Each production sector uses approximately thirteen factors of production:

1. Labor
2. Professionals
3. Capital equipment
4. Services
5. Buildings
6. Knowledge
7. Land
8. Transportation
9. Energy
10. Materials (raw materials or in-process goods)
11. Resources
12. Short-term loans
13. Long-term loans

Note that the last two factors above are taken from the financial sector of the National Model.

Linkage between production sectors is accomplished through four channels. These are backlog, delivery delay, price and factor payments.

The production sector is designed to represent realistic decision making. Mass writes:

> The production sector embodies a detailed behavioral theory of the firm. No a priori assumptions are made that production activities are in equilibrium or that business enterprises are geared only to short-term profit maximization. Rather, the sector is formulated to represent the way in which real corporate decisions are made. A principle for structuring the sector is that every piece of structure and every assumption should correspond to an identifiable real-life process and an identifiable decision maker. That is, the sector should portray the information that is actually available at the decision point and how that information is processed to yield decisions. The sector is

> also structured so that each parameter has operational and managerial significance, rather than just statistical interpretation. (p. 12)

The production sectors that Mass describes may be very useful in future post-attack system dynamic modeling efforts to construct multiple producing regions of the nation with interchange between the regions.

Carl F. Miller and Richard K. Laurino, <u>A Concept for Post-Attack Operations</u>, The Dikewood Corporation, Final Report on Contract DAHC20-72-C-0313, 1973.

Significant elements of this report are that it:

- Divides areas into undamaged, radiation exposure, and damaged (includes blast and fire)
- Specifies actions to be taken in a four-step Sequential Recovery Process (p. 14)
  - -- Secure essentials for continued short-term survival
  - -- Restore domestic service-utility base
  - -- Organize and deploy the surviving work force for short-term basis to prepare for industrial production
  - -- Organize and deploy the surviving work force to operate economic and industrial system
- Builds up some difference or differential equations for some elements of the economy
- Goes into great detail regarding recovery by the government sector
- Assumes the Federal Government survives although state or local government may need to control briefly
- Assumes no communication, transportation or behavior problems

This last assumption is quite unrealistic. In this paper, post-attack recovery seems to be a minature version of pre-attack operation.

Lucien N. Nedzi, Chairman, Subcommittee on Military Installations and Facilities of the Committee on Armed Services, Hearings on Military Posture and H.R. 10929, Department of Defense, Authorization for Appropriations for Fiscal Year 1979, H.A.S.C. No. 95056, Part 6 of 7 Parts, Civil Defense, Title VII, 1978.

Testimony was given by Brigadier General James Thompson and Bardyl R. Tirana, Director of Defense Civil Preparedness Agency.

The hearings focus on:

- 1979 budget request of $96.5 million plus $40.5 million more for expansion of Civil Defense
- Dispersion of Five Year Plan expanding $230 million more
- Details of warning system, shelter markings, etc. effectiveness of the current plan
- Dual use systems - for non-nuclear civil disaster
- Reorganization resulting in FEMA (Federal Emergency Management Agency)
- Crisis Relocation Program

Jiri Nehnevajsa with George Rogers and Steven Manners, Issues of Civil Defense: Vintage 1978 -- Summary Results of the 1978 Survey --, University Center for Social and Urban Research, University of Pittsburgh, Prepared for DCPA, 1979.

In late 1978, 1620 Americans were surveyed in the contiguous 48 states on key civil defense issues. The 1978 data show essentially the same results as earlier studies (1963-1972); i.e., strong support (65 to 85 percent) for civil defense measures that increase survivability from a nuclear attack. Support was strong for both sheltering and crisis relocation. A telephone survey of 300 people in Missouri yielded similar findings.

For example (p. 58), 78.2 percent of the national and 83.0 percent of the Missouri sample said that the nation should definitely or probably have such plans when asked "Should then the nation be preoccupied with crisis relocation planning?"

C. R. Neu, Economic Models and Strategic Targeting (U), The Rand Corporation, R-1846-ARPA, June 1976, SECRET.

Although this report is interested in economic models from the point of view of how they can be used to guide targeting policy, this report presents an excellent review of the types of economic models available and the problems associated with each. Neu comments that it would be fruitless to attempt to build a purely economic model of recovery as such, since it is exactly those aspects of the economic system which have proved most difficult for economists to treat adequately -- organizational structures, transportation, information flows and resource allocation mechanisms are likely to be most seriously disrupted and thus, of the greatest importance in the process of regrowth.

Neu sees little hope of predicting actual post-attack investment behavior. He suggests two alternatives in view of this. One approach would be to credit an economy with decisions which are in some sense optimal. This would provide an upper bound on the rate of recovery. Another approach is to deal with the whole range of possible states which the recovering economy could reach in a given length of time. This range is known as the feasible set for an economy at any given time. The principal difficulty involved in dealing with the entire feasible set is that it will, in general, be massively large and complex. However, if relatively small models are employed, perhaps the computations and interpretations could be accomplished sufficiently well to give a broad outline of the boundary of the feasible set. If one is forced to abandon the hope of predicting the investment in individual sectors, one is forced to a much simpler and more highly aggregated model. This, however, is the sort of model for which identifying a number of points along the frontier of possibilities becomes a realistic possibility.

The report outlines two types of models: a detailed model of post-attack output and a less detailed model of economic recuperation. Neither model is developed to the point where it could be useful for our purposes. Nevertheless, Neu's argument for choosing the particular recovery model that he uses is convincing, and we believe that further development of this model would be worthwhile.

Neu argues that a closed model of recovery should be used. Many models currently in use for recovery analysis are not closed; usually labor is assumed to be available exogenously and personal consumption requirements are fixed exogenously. The implications of a non-closed model are that the two likely reasons for the failure of a nation to survive -- the absence of an adequate work force and the presence of too many mouths to feed -- are eliminated right from the start. Neu states that there is no reason whatsoever to assume that recovery will in fact take place, and a useful model should be able at the very least to distinguish a pattern of destruction that precludes any chance of recovery from one in which recovery is possible.

Neu claims that it is out of the question to trace out the boundary of the feasible set of an economy after a given number of years or to choose a variety of points which are of particular interest and ask how long it will take the economy to reach them. While an optimization can theoretically be carried out through dynamic programming techniques, the computational requirements for models with more than four or five sectors become enormous. Consequently, the model in this report maximizes the weighted sum of the various commodities produced at the end of a fixed time period. By varying the weights, the rough shape of the relevant sections of the feasible set will be found. This approach allows the problem to be reduced to a manageable linear programming problem. The basic equation used

for output is similar to that of an input-output model except that a term is added for the growth in output. Thus, this model is not a static model. Also, this model can take into account inventories that exist or are built up during the period of interest.

Peter G. Nordlie and S. D. Vestermark, Jr., Civil Defense in Post-Attack Society, Human Sciences Research, Inc., 1967.

This summarizes research from a long-term research program on the likely social and psychological effects of a nuclear attack, social vulnerabilities of the American society to nuclear attack, and the problems of societal recovery from nuclear attack.

Some of the authors' ideas include:

- An Orphan Assignment Plan
- A Regional Recovery Plan
- Criteria for Recovery and Costs of Recovery Programs
- A recovery-oriented approach to civil defense planning and research
  - -- Recovery Goals
  - -- Recovery Requisites - people, resources, organizational capabilities, recovery management capabilities

Office of Emergency Planning, OEP Circular 5600.1C, National Objectives and Subobjectives for Civil Emergency Preparedness, June 14, 1968.

This circular describes national objective and subobjectives for civil emergency preparedness. The ultimate or overall objective is:

> To achieve and maintain national preparedness to support various degrees of mobilization of our human and material resources as may be required to deal with a full range of international or war situations in order to meet essential human needs, to preserve our democratic institutions, to enhance our way of life, and to survive as a free and independent nation.

Three national objectives are given. These are:

I. Insure the capability of essential government institutions to function across the full range of emergency conditions.

II. Develop and use the resources of the United States to achieve national security objectives including:

A. Analysis and projection of relations between resources and requirements;

B. Development and maintenance of resource strength through resource management; and

C. Economic stabilization by means such as restraint of inflation, control of money, credit and banking, and use of fiscal policy.

III. To protect the people of the United States against nuclear attack and provide emergency lifesaving services by means including shelter systems, warning and instructions, and provision of emergency services.

These objectives provide an overall framework for the OEP circulars described in these next pages.

Office of Emergency Planning, OEP Circular 7300.1, Emergency Preparedness Test and Exercise Program for the Executive Branch of the Federal Government, April 20, 1964.

This circular provides for periodic emergency preparedness tests on a nationwide basis. The tests and exercises are to be non-military and held regionally as well as nationally. No details or specifications are given.

Office of Emergency Planning, <u>OEP Circular 8500.6, Procedures for Regional Field Boards in Crisis Management Operations</u>, August 25, 1972.

The purpose of this circular is to provide guidance to the field for Federal action to prevent or combat <u>shortages in resources</u> or services which may effect the national health or well-being. Natural disaster caused emergencies are not covered here. The circular describes the organization and operations of Regional Field Boards and the relations among these Boards, state and local governments, and parts of the private sector.

Resource crises addressed include:

- Fuel Shortages
- Power Deficiencies
- Transport Stoppages
- Major Industry Stoppages
- Hazardous Health and Environmental Conditions.

Action phases by the Field Boards include a voluntary action phase followed by a priorities and mandatory allocations phase. The operation roles and responsibilities of particular agency and department representatives on the Field Boards are given in relation to specific types of crises.

This circular provides a general framework for organizing to deal with resource or environmental crises but gives little specific guidance for actions. The claim is made that management through the Joint Board and Field Boards worked well during resource problems that occurred in 1969 through 1971. Yet this organizational approach to resource crises does not appear to have been used during the 1979 gasoline and diesel fuel shortages.

Office of Emergency Planning, OEP Circular 9100.4, Federal Preparedness Planning and Emergency Operations at Regional Level, June 27, 1973.

The purpose of this OEP circular is threefold: (1) to establish policy to carry out Federal regional emergency preparedness planning and emergency operations; (2) to provide for continuity of the non-military elements of the Executive Branch of the Federal Government; and (3) to provide for OEP regional coordination operations under crisis or emergency conditions, including use of alternative regions with unusable offices.

In this circular is a list of Federal Departments and Agencies with "essential uninterruptible functions during the trans-attack and immediate post-attack periods." Ten department and fifteen agencies are on the list. The inclusion of agencies such as NASA, the Verterans Administration, the Environmental Protection Agency, and the Civil Service Commission on this list makes one curious as to the criteria used for ascertaining "essential uninterruptible functions."

Office of Emergency Planning, OEP Circular 9130.3, Organizational Arrangements and Procedures for the Coordination, at the National Level, of Federal/Civil Emergency Actions, February 8, 1973.

This circular prescribes organizational arrangements and procedures for facilitating decision-making and coordinating civil emergency measures by Federal Departments and Agencies during emergencies. Provided are a center for coordinating emergency operations at the national level plus an interagency emergency coordination group and a policy board.

Office of Emergency Planning, OEP Circular 9410.1C, Federal Civil Readiness Levels and Actions in Response to Official Instructions in an Emergency.

This circular describes a system of Federal civil readiness levels and provides policy and procedural guidance to Federal departments and agencies responsible for nonmilitary defense activities in an emergency. Readiness levels described are a communications watch, an initial alert, and an advance alert. Also covered are movement to alternate location duty stations and the relation of warning conditions and notices to the readiness levels and movement to alternate stations. Little detail is provided.

Edgar A. Parsons, Movement and Shelter Options to Reduce Population Vulnerability, System Science Inc., Report No. 27, 1970.

This report builds the case for movement and shelter options as an adjunct to the community shelter Planning Program. Movement considered is from potential nuclear blast areas to rural areas with shelters. The attacks used were OPAL-61 and UNCLEX-66. Casualties from these attacks were calculated by their DASH computer program for a variety of movement and shelter options. Parsons concludes that if a 75 percent evacuation of the population were combined with PF20 rural fallout shelters, then nearly 50 million (40 percent) of the preattack population at risk could be saved. The study considers the cost of this movement shelter option to be low compared to the reduction in casualties.

J. Pettee et al., PONAST II, Office of Civil Preparedness, 1972.

The PONAST II study was prepared by an interagency study group in response to a request by the Joint Chiefs of Staff. Twenty-two government agencies made contributions to the study. The study was under the overall direction of a steering group, consisting of members from the Office of the Assistant Secretary of Defense (Systems Analysis), Defense Intelligence Agency, Defense Communications Agency, Defense Civil Preparedness Agency, Office of Emergency Preparedness, State Department, Central Intelligence Agency, and chaired by a representative of the Joint Chiefs of Staff.

PONAST II is a study of the survival and recovery prospects of the United States and the Soviet Union, following a hypothetical massive nuclear attack on the United States by the Soviet Union, which, in turn, is quickly followed by a U.S. counter-attack on the U.S.S.R. One of the principal purposes of the study was to provide insights useful for U.S. nuclear contingency planning. This review deals only with the hypothetical attack on the U.S. It should be noted, however, that current Soviet civil defense plans, which consist basically of evacuating their larger cities, were found to be highly effective in limiting the number of Soviet casualties.

PONAST consisted of a computer simulation of the nuclear exchange. The assumed magnitude of the attack and counter-attack was what might reasonably have been expected if a war had actually occurred in early 1971. It was assumed that the U.S. evacuated 10 percent of their cities with populations over 100,000 and that the Soviets evacuated 70 percent of the people in similar size cities. The attack of the United States consisted of 1,400 warheads, containing 6,800 megatons. The Soviets applied about one-third of their megatonage to urban/industrial targets in the U.S., the remainder

being applied to U.S. military targets. There were 94 million fatalities in the United States. Of the 109 million survivors, 35 million were injured. About three-quarters of the fatalities and three-fifths of the nonfatal injuries were caused by prompt weapons effects. The remainder were caused by fallout.

A number of excursions were carried out to investigate alternative civil defense measures in the United States, and the cost and effectiveness in terms of surviving population are compared for these alternatives. Both evacuation and shelter are considered. One evacuation program increased the percent surviving from 54 percent to 93 percent, while increasing the cost per survivor from the base case of about $10 to about $50. This posture assumes 100 percent evacuation of the metropolitan areas with everyone in fallout shelters with a protection factor of 40 or better. The results of the study showed that reconstitution of the national government was possible. The criterion used for national survival was the viability of the major metropolitan area.

As far as radiation hazards were concerned, 35 of the 230 SMSA's were available for industrial production immediately after the attack, while production from the 21 most heavily affected SMSA's was considered to begin one year after the attack. The average radiation dose to the U.S. survivor was 170 roentgens. This would increase the death rate due to cancer and leukemia, and decrease the life span of survivors by an average of four and one-half years. Forty-five SMSA's had no surviving local goverment and, in almost all of these, no EBS stations survived to provide guidance to the public. In 58 SMSA's, although the major city and county governments were lost, one or more suburban governments remained functional. It was calculated that approximately 700,000 military personnel would be needed to assist the SMSA's in law and order capacities!

Medical and health care problems were considered to be the most crucial in re-establishing SMSA viability; the sharpest reduction in health care occurred because of the shortage of physicians. There were 27 million homeless persons. In 15 SMSA's, which included one million survivors, there were no surviving dwellings at all. The surviving work force in the 29 largest SMSA's averaged 27 percent. However, in only five areas did the labor force suffer a greater reduction than the reduction in labor force requirements as indicated by the survival of industrial plants. Thus, shortages could be expected in particular skills, but numerically the labor force was adequate. Twenty-one percent of the pre-attack manufacturing capacity was viable after three months, and 27 percent was viable at the end of 18 months.

Nationwide, 44 percent of the labor force survived. Agriculture and food stocks survived at a greater rate than the population. The sources of fuel survived, largely intact, but serious losses in petroleum refining and storage required priority attention by the national government. The transportation networks, rail and highway, survived very well. Most service functions survived better than most categories of production facilities, a major exception being in the health service field. The study also looked at the surviving capabilities for assembling data, assuring ownership and control of facilities, provision of credit, and fiscal responsibility.

As part of PONAST II, a study was conducted to assess the social and psychological impact of a massive nuclear attack on the United States. A cross-section of government and civilian experts was queried. The consensus was that there would not be a collapse of our society. The major obstacle identified was the ability of the government to communicate

with its citizens in order to overcome the greatest psychological barrier identified in the study - fear.

The first six months of the post-attack period was assumed to be the survival period. Some production would be able to be resumed during this time and, by the end of this period, sufficient production capacity, as well as government and communication functions would have revitalized to enable the economy to become basically self-sustaining. Thus, the U.S. would no longer be primarily dependent on the limited supply of surviving pre-attack inventories for meeting survival requirements.

The recovery goal established for this study was the restoration of the pre-war standard of living per capita for the surviving population. The U.S. civil recovery effort began with 27 percent of surviving capacity, which is sufficient to maintain a standard of living at about the per capita level of the mid-30's in the first year. In the sixth year, the civil recovery would have approximated a 1965 per capita standard of living, except for automobile production. In the seventh year, full civil recovery to 1970 per capita expenditure levels was estimated to be accomplished.

Pettee, James C., Unclassified Nuclear Case-Lesson Example of 1973 (UNCLEX-73), Volume I, Scenario and Attacks for UNCLEX-73, June 1973, and Volume II, National Survival After UNCLEX-73, November 1978, Federal Preparedness Agency (both volumes).

Two 1200-weapon, 6000-megaton attack designs are considered in this study. Attack "Mike" has 2/3 counterforce targeting and 1/3 countervalue targeting, while the proportions are reversed for the "Charlie" attack. The scenarios included a crisis building over several months with two weeks of alert status before a short duration attack. A brief description of the weather and detailed computer listings, weapon-by-weapon, for the two attack designs complete Volume I.

The objectives for this exercise stated in Volume I included providing unclassified examples for analyses of postattack national survival and recovery. Volume II covers national survival, and Volume III, not yet seen, covers national recovery.

That these objectives are not being achieved too speedily is apparent from the publication of Volume II, over five years after Volume I. Given that input-output tables were used in the sector-by-sector analysis of survival, it is not surprising that the effort was lengthy.

The survival analysis indicated that capacity balance comparisons for the two attack designs reveal comparatively deep cuts in six vital manufacturing centers: drugs, petroleum refining, equipment production for communication electronics, equipment production for electric power distribution, and major military equipment production. The threats that such shortages pose to national survival are suggested but deemed conjectural or scenario dependent.

Volume II summarizes that "the most serious threat to national survival reflected in these two case studies probably lies in the tremendous institutional improvisation and reconstitution requirement which must be met by a very severely reduced governmental structure." In view of this, it would have been interesting to study survival as a function of government capability with government capability measured by the extent of its operating command, control and communications ($C^3$) system.

Geraldine Petty, Lilita Dzirkals and Margaret Krahenbuhl, Economic Recovery Following Disaster: A Selected Annotated Bibliography, Rand Corporation, Report R-2143-ARPA, 1977.

This report contains a selected, annotated bibliography of literature related by the title theme of economic recovery following disaster. The literature includes German and Russian literature on recovery following World War II, although some Russian literature on economic recovery in the Soviet Union in the 1920's is also included. Other World War II recovery literature surveyed includes France, Japan and several other European countries.

The other sections of this review cover hypothetical war produced disasters and natural disasters.

The Soviet and German-Austrian literature is well summarized. Perhaps their most salient comment in regard to Soviet civil defense is:

> It appears that lessons of World War II recovery affect Soviet planning. This can be seen in their efforts to disperse production and labor resources throughout the vast territory of the U.S.S.R., exemplified by current regional and new economic planning that stresses horizontal integration of hinterland industrial complexes and their auxiliary resource bases.

Walter Pincus, "Civil Defense Scenario Imagines Life After A-Bombing," Washington Post, 23 May 1979.

This article summarizes the Office of Technology Assessment's Charlottesville, Virginia scenario where a 4,000 megaton Soviet attack kills nearly 100,000,000 people and a U.S. attack has similar effects. The evacuees flee heavily damaged cities for lightly damaged ones like Charlottesville. Hospitals fill quickly to overflowing and medical supplies near exhaustion. After three to four weeks, people emerge from shelters. Food and money pose problems. Cottage industry and agriculture develop. Schools remain closed. Government is slowly reconstituted. Survival is uncertain.

The complete text of the Charlottesville scenario is contained in Appendix C of Peter Sharfman et al, The Effects of Nuclear War, Volume I, Office of Technology Assessment, 1979.

George E. Pugh, _Dynamic Post-Attack Economic Model: A New Analytical Approach_, Decision Science Applications, Inc., Report No. 82, 1978.

The author describes preliminary results of a model using "Lagrange Dynamic Programming" which is actually sequential optimization with a nonlinear objective function. The objective function is the total integrated utility over selected economic activities. An appropriate discount rate is assumed. He claims superiority over econometric, I/O and linear programming models. His claim is not well substantitated.

The model has three sectors:

- production of consumer products and services
- production of housing
- production of industrial factories

Recovery time is investigated as a function of capital allocations.

Pugh-Roberts Associates, Inc., DCPA Quarterly Progress Report No. 2, 1979.

This reports on development of Pugh-Roberts System Dynamics model for post-attack U.S. economic recovery. The model started with three sectors:

- economics
- population
- psychological effects.

A section on socio-political effects has been added based on historical broad-scale disasters. The model is becoming more detailed as sectors are broken down.

George H. Quester, Options for Accelerating Economic Activity after a Nuclear Attack, Report AAC-TR-9203/79, Analytical Assessments Corporation, Marina del Rey, California, July 1979.

This report suggests and discusses some eighteen relatively low-cost innovations in administrative procedures or political arrangements that would accelerate economic recovery in the U.S. following a nuclear attack. These arrangements are to be viewed as "dual purpose" in the sense that they are useful or at least not a burden in the pre-attack normal environment. The problem of preparing for post attack recovery is seen to have a large psychological component.

Possible innovations discussed are:

1. upgrading telephone and other communication systems;
2. establishing more survivable and redundant banking systems;
3. ensuring reliable property records;
4. preparing alternative monetary arrangements;
5. exploring government policy choices on credit and debt,
6. arranging alternative securities and futures markets;
7. ensuring a reliable war-damage sharing system;
8. expanding backup radio and television communication systems;
9. providing for backup legislative, executive, and judicial arrangements for Federal and state governments;
10. preparing contingency rationing systems;
11. examining economic and policy options in transportation;
12. developing an information system for the labor force;

13. considering fallout shelter construction and other underground construction;

14. studying economic and government policy options on food supply;

15. preparing for backup police power arrangements;

16. examining policy choices on foreign trade;

17. considering advance contingency contracts between government and private firms and among private firms specifying production shifts in an emergency; and

18. evaluating government policies that might indirectly lead American firms and households to stockpile commodities for survival.

Each of these possible areas of innovation is considered as dual purpose, i.e., useful for natural disasters as well as nuclear attack. Also, each possible innovation is discussed in behavioral terms as well as in political and economic contexts.

These provocative possibilities lead one to ask, how much cost and effect each innovation would have? They merit further assessment.

Edward B. Roberts (Ed.), Managerial Applications of System Dynamics, MIT Press, Cambridge, Massachusetts, 1978.

This book is a collection of 36 system dynamics papers of which 13 are written or co-authored by the editor, himself. Application areas include urban transportation, the U.S. plywood industry, R&D management, corporate growth, and corporate long-range planning.

Joseph Romm, An Overview of Political, Social and Public Acceptance of Civil Defense, Systems Sciences, Inc., 1969.

This report summarizes legislation and authorizations for Civil Defense from 1951 to Fiscal Year 1970. The only year the Federal appropriation was over $113 million was $207.6 million in the 1962 budget following the Cuban Missile Crisis. At State and Local levels, it is noted that CD orientation is a mix of defense and natural disaster. This dual role has helped support and gain acceptance of CD at the State and Local levels.

A 1969 survey of 8.7 million home owner questionnaires with a 74 percent return (6.4 million) yielded only 12,511 negative responses regarding the questionnaires.

If a new or accelerated civil defense program is to succeed, it must have as many of the characteristics below as possible:

- Contribute to Defense Posture
- Have a peacetime dual-use
- Have moderate cost
- Have the majority of its funding from the Federal Government
- Not attempt to involve the public too deeply or for too long a time

And most importantly,

- Must have continuing active support of the President, not to "sell" the general public, but to convince the Congress.

Donald E. Sexton, "Evaluating Urban Growth Policies with a Systems Simulation," Management Science, Vol. 25, No. 1, January 1979, pp. 43-55.

Sexton developed and exercised a System Dynamics model of a single city and country in order to evaluate urban growth policies. The model consisted of four sectors--national services, local services, manufacturing, and population. Urban growth policies investigated included restricting growth of manufacturing and/or government activities in the capital, moving government services from the capital, lowering the national birth rate, and making cities other than the capital more attractive places to live.

In contrast to Forrester's Urban Dynamics, Sexton expresses both concern for obtaining empirical support for some of the relationships used and caution with regard to conclusions drawn.

> This study was performed in the context of a single city and country. As such, the results can be extrapolated only with much care. However, the model did produce broad insights into the interaction of several types of policies. These findings clearly demonstrate the need for coordination of such policies if urban growth is to be controlled.
>
> Much further work can be done with this model. For example, policies can be varied over time and other policies, such as those aimed at increasing productivity can be investigated. In addition, the model itself can be extended to include more detail regarding industries, resource usage, and the behavior of the population. Finally, further empirical support can be obtained for some of the relationships used.

Peter Sharfman et al. <u>The Effects of Nuclear War, Volume I</u>, Office of Technology Assessment, 1979.

This report, utilizing several consultant reports, addresses the difficulties of calculating the effects of nuclear war on both the U.S. and U.S.S.R. under a variety of attack scenarios - one city, petroleum refining, counterforce, and a large attack against a variety of economic and military targets. All attack scenarios assume that the Soviets attack first.

The report also includes a tutorial on nuclear weapons effects, discussion of both U.S. and Soviet Civil Defense, and consideration of long-term effects. Appendix C is Nan Randall's "Charlottesville: A Fictional Account," describing the post-attack life of a city not directly hit but severely affected nonetheless by nuclear attack.

The findings of this report raise more questions than they answer. For examples, "The effects of nuclear war that cannot be calculated are at least as great as those for which calculations are attempted" and "Although it is true that effective sheltering and/or evacuation could save lives, it is not clear that a civil defense program based on providing shelters or planning evacuation would necessarily be effective."

Bets are not hedged on the extreme vulnerability of both the U.S. and Soviet oil refining capacity and these vulnerabilities are described in detail.

James W. Sinko and L. D. Bryson, The Recovery of Cities from Natural Disasters: A Conceptual Model, Stanford Research Institute, 1970.

This report surveys historical examples of destruction of substantial portions of the industrial output of cities due to natural disasters or wars. Examples include San Francisco (1906 Earthquake), Hiroshima (1945 Atomic Bomb), Nagasaki (1945 Atomic Bomb), Tokyo and Osaka and St. Pierre Martinique (1902 Volcanic Eruption). Except for St. Pierre which lost 100 percent of its population, all recovered pre-destructive event GNP within 6 to 8 years.

For our purposes, the greatest significance of this report lies in the type of model that it constructs for economic recovery. Although written for the IBM 360/CSMP (Continuous Systems Modeling Program), Sinko and Bryson's model contains many elements that are common to the system dynamics models of post-attack economic recovery now being constructed by Pugh-Roberts and Analytical Assessments.

The Sinko and Bryson model considers the allocation of workers between essential services, construction, and industrial production. The model assumes that the essential services sector of a city, which includes waterworks, sewers, electricity, streets and communications, will have first priority on restoration efforts. The demand for essential support services immediately following the attack will be greater than it was before the attack. Consequently, workers from the industrial production and construction sectors will have to be trained in the essential services sector. Similarly, the demand for construction workers will be greater after the attack than before. The model assumes a function for the distribution of time that it takes for a worker from one sector of the city to retrain and relocate into another sector of the city.

It then combines this training time with the time distribution of demand for workers in these three sectors and determines the time it takes before workers are released back into the production sector.

The specific model developed in this report is too simple to be of any utility for our purposes, but it could be extended in a straightforward manner to model the survival and reorganization phases of recovery.

A useful annotated bibliography is appended.

B. Sobin, Post-Attack Recovery, Research Analysis Corporation, RAC-P-51, June 1970.

This paper is a written version of an oral presentation for an Office of Civil Defense Workshop on economic problems for an audience of architects and construction engineers. This a brief paper yet it provides an excellent introduction to the subject of post-attack recovery as well as a framework for viewing that subject. The framework includes a definition for successful recovery that requires meeting two viability conditions: (a) losses of populations due to failure of the economy to support those surviving the shelter period have been negligible, and (b) future production of goods and services sufficient to meet consumption requirement of government agencies and of the population indefinitely is assured. The paper states that the critical issue in recovery is whether the minimum requirements of the country can be assured. It discusses reasons why, if the minimum requirements are assured, subsequent increases in national income are likely to be rapid.

Two broad classes of economic recovery problems are discussed in this paper: (a) physical capabilities of surving resources to meet minimum requirements if they are used in optimal ways, and (b) effectiveness of the economic organizations and government policies in taking advantage of the underlying capabilities of the surviving resources. We believe that these are the two critical problems that have to be dealt with in any study of national survival and recovery.

This paper does not develop any specific models of the recovery period, but it lays out the following basic inequalities that must hold for any model of recovery:

Human and other durable assets

Inputs to production + Other uses $\leq$ Stocks

Services

Inputs to production + Other uses -
Outputs of production $\leq$ 0

Consumable commodities

Inputs to production + Other uses -
Outputs of production - Inventory
depletions $\leq$ 0

Inventory depletions $\leq$ Stocks

This paper concludes with the following observations:

Physical Capabilities

"Models exist and are improvable for estimating the physical capabilities of the economy after nuclear attack. The models exercised so far indicate strongly that, with the attacks ordinarily considered. physical capabilities are more than sufficient to meet minimum survival needs of the population. Of course, the ability to add military and other burdens beyond survival is limited. Without these other burdens, there should be substantial slack for investment and economic growth. If this investment is applied to bottleneck industries, the payoff in economic growth should be much higher than in peacetime."

Management Efficiency

"The situation is not so clear with respect to management efficiency. No way now exists for measuring the

extent to which resource management problems will degrade the performance of the economy under either present plans or possible alternatives. What does seem establishable is that the extensive official planning already completed for post-attack management of the economy would set up a system having major, demonstrable dangers. Unfortunately, no clearly superior alternative management system has been proposed."

This rather short paper has been given a long review because it gets at the essence of the problem of analyzing post-attack survival and recovery better than any other paper we have found. It suggests to us that a good way to break down the analysis would be to separate the problems in management efficiency from the rest of the analysis. To do this, our model of technological capabilities of the economy should assume that resources are used in optimal ways, and the actual performance of the economy should be determined by multiplying this capability by appropriate factors for management efficiency. This approach has much intuitive appeal because the accuracy with which we can estimate the physical capabilities of the economy is quite different from that with which we can estimate management efficiency. By breaking the problem into these two parts we will have a better estimate of the overall accuracy of the results that we would have if these two parts were indistinguishably intermingled.

Bernard Sobin and David F. Gates, Economic Implications of High Population and Low Property Survival in Nuclear Attack on the United States, Research Analysis Corp., Report RAC-TP-317, 1968.

This (partly classified) report employs an input-output model of the economy with a linear programming portion that chooses combinations of activity levels that maximizes the number of survivors subject to resource restrictions. The data used are generally 1963-1965 ratios for agricultural production and food processing and 1958 for the balance of the economy.

In their summary, they claim that "the basic weakness of present post-attack labor-management plans is that the provisions that have been made are generally designed to deal with the problems of a World War II mobilization or a conventional post-attack situation in which labor is scarce relative to capital." They recommend measures to study and encourage substitution of labor for capital.

State of Texas, _Disaster Preparedness - Plans and Operations Workshop_, Texas Division of Disaster Emergency Services, 1978.

This workbook provides a detailed format for a multi-meeting workshop to enable local (city/council) governments to produce written plans, annexes and standing operation procedures (SOP's) to deal with natural or war disasters.

Maynard M. Stephens, Vulnerability of Total Petroleum Systems, Department of Interior, Office of Oil and Gas, Prepared for Army Office of Civil Defense, 1973.

Stephens studied the total petroleum industry including production, refining, transportation and marketing. He focused on the impact of a nuclear attack on the petroleum system within the State of Louisiana. He concluded that this industry is extremely vulnerable due in part to the delicate nature of computer controlled refineries, the industry's concentration, and vulnerability of its pipelines and water transportation system.

This very thorough report included charts relating to blast over-pressure to damage, and repairs to labor required.

Lack of security in the pipeline system is cited. A useful annotated bibliography is appended.

Although this report contains data on the output of the petroleum system, it does not speculate on how reduction of that output would impact the rest of the economy.

Maynard M. Stephens a.d Joseph A. Golasinski, Vulnerability of Natural Gas Systems, Department of the Interior, Office of Oil and Gas, Prepared for Defense Civil Preparedness Agency, 1974.

This report describes the U.S. natural gas industry in detail and cites its vulnerability to disruption by sabotage or by nuclear attack. The pipelines and compressor stations are noted to have little or no security. Also major pipelines have no standby equipment or alternate routes. Domestic supplies of natural gas are largely drawn from Louisiana and Texas.

The concentration of supplies and the lack of backup equipment make the industry extremely vulnerable to nuclear attack. The author recommends a contingency plan to devise methods to use substitute fuels for natural gas in places where a storage of natural gas would cause serious problems.

Large gas processing plants, to remove impurities and sort out other salable gases and gas liquids are analogous to oil refineries and are just as vulnerable to nuclear attack.

"The vulnerability of the field gas system...is essentially the same as the vulnerability of the crude oil system" discussed in Stephen's 1973 report.

Eighteen months is estimated as the time to rebuild a destroyed processing plant assuming normal delivery of equipment and materials.

Roger J. Sullivan, Winder M. Heller, and E. C. Aldridge, Jr., Candidate U.S. Civil Defense Programs, Systems Planning Corporation, Report 342, 1978.

In some ways an update of PONAST II, this report analyzes the candidate U.S. civil defense programs under a mid-1980's Soviet attack versus both counterforce and countervalue targets. Two attack scenarios included counterforce and countervalue targeting, with the first having targeting of residential population and the second targeting of relocated population. Six specific civil defense programs were used along with two options to these programs. The six civil defense programs were:

- No civil defense
- Current civil defense program
- Best use of existing shelters by in-place population
- Relocation of risk area population to rural areas with some fallout protection
- Risk area population relocated to a lesser extent but provided 15-psi blast protection
- Extensive blast shelter program with protection of 100 psi and PF500.

The two options involved:

- Incorporating blast and fallout shelters into new construction; and
- Preparing contingency plans for a one-year buildup of civil defense capabilities.

The primary feature of the second option would be buying material for crisis construction of expedient shelters, i.e., 15 psi and 100 PF.

Casualties ranged from 80 percent of the population for Program A to 60 percent for C to 20 percent for E (without retargeting relocated population) to 10 percent for Program F. Estimated program costs in 1979 dollars were:

$\sim$ .05 Billion for Plan A;
$\sim$ .8 Billion for Plan B;
$\sim$ .9 Billion for Plan C;
$\sim$ 2.0 Billion for Plan D;
over 10 Billion for Plan E; and
$\sim$ 80 Billion for Plan F.

The graphs of costs and casualties for the six plans would appear on the surface to be sufficient to enable the appropriate decision maker to express preferences and tradeoffs. However, the pertinent result space has more dimensions. Perhaps a key dimension omitted in this analysis is likelihood of an attack.

Roger J. Sullivan, Charles W. Hulburt, Mickey O. Marshall, Gordon H. McCormick, and Earl V. Sager, Civil Defense Needs of High Risk Areas of the United States, Final Report SPC 409, System Planning Corporation, Arlington, Virginia, March 1979.

This report studies U.S. civil defense measures available for areas containing significant portions of the U.S. strategic nuclear retaliatory forces or significant defense-related laboratories or other defense facilities. Damage estimates are prepared for counterforce attacks for several different length warning periods and for current civil defense and several alternative civil defense plans.

The report:

(1) identifies the areas of the U.S. containing U.S. strategic nuclear retaliatory forces or significant defense-related laboratories or other defense facilities including nine strategic missile fields, 36 SAC bases, two strategic submarine bases, and 80 defense related facilities;

(2) determines existing and planned civil defense evacuation, shelter and warning plans for these areas;

(3) evaluates the effectiveness of existing plans and systems with a close look at plans in New Mexico and Missouri;

(4) determines the feasibility of more effective civil defense plans for these areas with associated costs on a cost per person basis;

(5) analyzes the potential effects of a nuclear attack on these areas in terms of fatalities and injuries but not property damage; and

(6) studies the need for public information, training and education on civil defense for these geographic areas and finds that "existing public attitudes exhibit strong approval of civil defense efforts but little understanding or knowledge of what would be required to implement them.

The authors analyzed four civil defense plans:

- the current program
- crisis relocation
- expedient shelters
- dedicated blast shelters.

Three warning intervals were considered:

- 1-2 week crisis build-up
- 24 hour crisis build-up
- 15-30 minute warning prior to attack.

Key assumptions included:

- 80 percent of the population requested to relocate would relocate from the risk to the host area
- the maximum population of the host area after relocation would be six times the normal population.

They concluded (p. 24) that, "for a 1-2 week crisis build-up period, crisis relocation would be virtually as effective as the in-place shelter programs."

The report states that a balanced civil defense program needs systems for direction and control, warning, and radiological defense. The conclusion (p. 15) reached in this area of balanced

civil defense is that, "the current U.S. civil defense program is extremely austere and would not be able to function well under crisis conditions due to inadequacies in direction and control, radiological defense, and other systems. However, it does provide some basis for protecting people in-place and a modest start has been made on planning to add an option for crisis relocation." The program recommended by the Secretary of Defense and by the President in Presidential Decision PD-41 would rely on crisis relocation plus improved sheltering in host areas.

In the realm of costs of civil defense plans, the authors report that the U.S. now spends $.45 per person per year on civil defense. Further, improved civil defense in counterforce areas would require an annual per person expense of $.65 for crisis relocation to $2.70 for blast shelters. At the present rate of progress, crisis relocation plans for the entire U.S. would be completed in the early 1990's. If funding were doubled, planning time could be halved.

One of the more interesting results of this report concerns the dividing line between counterforce and countervalue attacks. The authors found (p. 89) that, "Missouri represents a case in which an essentially counterforce attack can result in casualty figures comparable to a counter-population attack." This is due to a strategic target, namely Whiteman missile complex, lying near a region of moderate-to-heavy population density.

In summary, the authors have taken several possible attack and warning combinations and assessed the effectiveness of present civil defense plans and alternative plans. Their assessment is not very favorable for present civil defense.

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Damages for the attack/warning combinations are presented graphically versus civil defense plans and their costs. This format of presentation has been seen before (e.g., in PONAST II). A powerful graphic that could be derived from the author's graphs would plot incremental cost per life saved by moving to the next most effective civil defense plan.

The authors should be praised for including behavioral analysis in the study, which they have done in their section on public response and civil defense effectiveness. There is little doubt that the effectiveness of any civil defense plan is dependent on public responses that are functions of training, education and available information. Fundamental research on the quantitative assessment of public response to civil defense actions would be extremely useful to model builders who must incorporate public response in their evaluation of alternative civil defense plans.

The considerably greater length of this bibliographic annotation is due to the particular timeliness and pertinence of this report to the civil preparedness aspects of our study.

Roger J. Sullivan, Jeffrey M. Rainey and Richard S. Soll, The Potential Effect of Crisis Relocation on Crisis Stability, System Planning Corp., Report 361, 1978.

The authors report on interviews concerning the potential effect of crisis relocation on crisis stability. Interviewed were authorities on crisis management, civil defense, national security policy and Soviet studies. Also, a review of the literature relevant to crisis relocation is included. Conclusions drawn with respect to the advisability of U.S. relocation in an intense crisis are:

- In the presence of Soviet relocation - put forces on alert and if the Soviets do not de-relocate, then the U.S. should relocate
- In the absence of Soviet relocation - relocate only under certain conditions, including:
    - -- strong strategic deterrent
    - -- U.S. strategic forces on alert and not highly vulnerable, etc.

System Planning Corporation, Impact of Enhanced Mobilization Potential on Civil Preparedness Planning, Draft Workshop Paper for Defense Civil Preparedness Agency, 1979.

This reports on a study to explore the impact of an enhanced U.S. mobilization potential (i.e., rapidly expanded industrial production of military equipment and weapons) on civil preparedness planning. It looks at different war scenarios with key variables of time and intensity of preparation. U.S. World War II mobilization as an example of the nation's capability is cited.

They estimate that the Soviets could increase their military industrial output by a factor of six within a few weeks of mobilization while the U.S. could increase by a factor of three during the same time. After a longer period of time, the U.S. could increase military output to 25 times the peacetime output.

By surveying the U.S. defense industry, no factor was found that could deter increasing military production potential to 25 times the current output given a year or two of planning for such an an increase.

System Planning Corporation, Impact of Enhanced Mobilization Potential on Civil Preparedness Planning, Phase 3, Workshop Talking Paper Draft, 1979.

This draft contains analysis only; no modeling effort was undertaken. It examines the impact of enhanced U.S. mobilization potential on civil preparedness planning. It identifies four major phases of any likely superpower conflict:

- pre-attack
- trans-attack
- post-attack
- post-war.

It looks at defense industrialization because it could figure strongly in all four phases. The U.S. and Soviet industrial potential is estimated. Soviet potential is higher in the short run but U.S. potential is greater in the long run (i.e., over five years to catch up in total inventories). It concludes that the U.S. is capable of activating a defense mobilization given a year or two of planning.

In the last part of the paper, the conclusion is reached that pre-attack mobilization could have a significant impact on civil defense planning by listing detailed actions for each. Coordination between mobilization planning and civil defense planning is favored.

System Dynamics Group, The System Dynamics National Project Annual Report, Massachusetts Institute of Technology, School of Management, Report D-2453-4, 1976.

This report covers work done on the national model from September 1975 to October 1976. A common basis for the three cycles in the economy is described. The cycles include Business, Kuznets, and Long Wave. The model is to be used to gain insights for inflation, unemployment and energy. Model sectors include production, labor, financial and household. Further detail on the production sector is given in Nathaniel Mass's "Introduction to the Production Sector of the National Model" which is also annotated in this report.

System Dynamics Group, System Dynamics Newsletter, Volume 16, System Dynamics Group, Sloan School of Management, MIT, Cambridge, Massachusetts, December 1978.

This issue provides a summary of past and current system dynamics efforts at MIT and at other institutions and organizations. Reports on teaching cover 19 institutions other than MIT. Of these 19, seven are outside the United States. Reports on system dynamics research come from 24 institutions and organizations outside of MIT. A rather extensive system dynamics bibliography is provided including books, published articles, conference proceedings, and meetings and working papers. This bibliography is a useful compendium of system dynamics development and applications over a 20-year period.

Given the length of time that system dynamics (formerly industrial dynamics before its generalization) has been around and its publicity, the number of institutions reporting on teaching and research appears small.

It is possible that some institutions doing system dynamics work are not listed (e.g., University of Bradford, England, see Coyle's book), but even if the number of institutions reporting were doubled, the number would appear small for a methodology that has had such wide public exposure. For some insights as to why the spectrum of users appears to be somewhat narrow, see the entries for Ansoff and Slevin, Buffa and Dyer, and Greenberger, et al.

L. S. Taylor, Chairman, Proceeding of the Symposium on Post-Attack Recovery from Nuclear War, Held at Fort Monroe, Virginia, November 6-9, 1967, Office of Civil Defense, 1967.

This symposium allowed many well-known participants to summarize their views. Papers are grouped according to sessions: sustenance, health, long-range effects, economics and societal vulnerabilites. Two example attacks were considered: CIVLOG (mostly counterforce) and UNCLEX (with half directed at the military, one quarter directed at the population and one quarter directed at industry.) The most serious of the post-attack recovery problems appeared to be management techniques - especially in motivation, incentives and behavior of all population levels.

Texas Division of Disaster Emergency Services, First and Second Quarterly Report, Prepared for Defense Civil Preparedness Agency, Contract No. 01-78-C-0321, 1979.

The first quarterly report details a relocation plan for San Antonio and an exercise to evaluate that plan. It was concluded that there was no insurmountable transportation problem to crisis relocation.

The second report detailed progress with regard to several emergency resource management tasks.

Adam Ulam, "U.S.-Soviet Relations: Unhappy Coexistence," *Foreign Affairs*, Special Issue on America and the World 1978, January 1979.

The author summarizes U.S.-Soviet relations in 1978. He mentions the Carter Administration's first priority was to reach a quick SALT II agreement, then takes up other issues between the two nations.

On page 561 he writes:

> If the Soviets had indeed forsworn a nuclear first strike and accepted the validity of mutual deterrence, then how could one explain their meticulous and costly civil defense preparations?

The author concludes that Moscow will reexamine its own foreign policy only when it is convinced that the American political system is capable of producing and adhering to realistic and consistent policies.

S. Winter, Jr., Economic Viability After Thermonuclear War: The Limits of Feasible Production, The Rand Corporation, RM-3436-PR, September 1963.

The main focus of this study is on the limits imposed on production in the post-attack economy by the availability of economic resources and the technological conditions of production. (By this, Winter means to say that he does not address the organizational aspects.)

Winter divides the recovery of a post-attack economy into three pahses: survival, reorganization, and recuperation. Winter's thesis is that if the country gets through the survival and reorganization phases with enough productive capacity established at the end of the reorganization phase to provide for the essential needs of the surviving population, the economy is viable and the recuperation will proceed without any serious threat to the viability of the economy. It can be expected that there will be a substantial period of time after an attack when the nation meets a significant portion of its essential economic needs out of inventory, and Winter views the struggle for viability as a race between reestablishing output adequate to meet the essential needs of the economy and the exhaustion of existing inventories. If the organizational problems of making effective use of the surviving resources are not solved in a way that raises output in time to the necessary level, Winter postulates that the economy will subsequently revert to a state of chaos and cumulative decline.

Winter builds a simple mathematical model of the factors affecting viability. He then discusses a number of factors that combine to make his model give an upper bound to the probability that viability will be achieved. Ayres claims that Winter's model does not necessarily give an upper bound, however.

In addition to providing a characterization of the viability problem at the theoritical and conceptual level, Winter provides a general quantitative perspective on the problem of achieving viability as it might arise in the United States after a thermonuclear war. He investigates the probable post-attack balance between population and other resource categories that would result at various levels of attack, and attempts to determine the levels of attack that might reduce the per capita availability of various resources to the danger level. The problem of post-attack food supply is considered in some detail, and the problems of "network industries" -- transportation, communications, etc. -- are discussed briefly. On the basis of these results, some tentative judgments are made as to the levels of attack at which viability would become unlikely in the absence of pre-attack preparations to facilitate reorganization. The dominating uncertainties in the picture are found to be those that have to do with the resumption of agricultural production. If measures could be devised and preparations made to assure that agriculture would not be drastically altered, then it appears that all other economic problems could be managed.

The approach used in Winter's report is substantially different from that used in the other analyses reviewed here. It appears to be one of the few attempts at analyzing post-attack recovery that gets at the problem of viability, without getting bogged down in so much detail that results are difficult to obtain, impossible to verify, and likely to be misleading because of the narrow scope of the model employed.

Sidney G. Winter, Jr., The Federal Role in Post-Attack Economic Organization, Rand Corporation, Paper P-3737, 1967.

Winter suggests coordination rather than control. He comments on the need for, extent of, and feasibility of federal government controls following an attack. He suggests that surviving federal capabilities be used to facilitate spontaneous recovery processes and influence decisions with largest national impact. Suggested government activities include:

- guiding public expectations;
- helping basic economic institutions recover;
- restoring legal and political framework;
- control and regulatory functions - pricing and allocations;
- making resources available for investment;
- blunt uses of government power.

M. K. Wood, "PARM -- An Economic Programming Model," Management Science, Volume II, No. 7, May 1965, pp. 619-680.

PARM was conceived and initially implemented (on the Univac 1103AS) as an inter-industry model suitable for illuminating the problems of post-attack resource amangement. It incorporates a detailed (466 producion activities) input-output table and proceeds iteratively, with the intervention of a decision-maker at each iteration, to find and to describe an objectively feasible and subjectively acceptable time-phased program for recuperation of the U.S. economy from attack damage. No overall optimizing criterion is assumed to be definable.

The model introduces a number of significant departures from the more classical Leontief formualations. For example, input coefficients are replaced by complex records that include lead-time parameters (in general, inputs to an activity are not concurrent with the associated output) and that may define a post-attack technological option differing from pre-attack technological practive. Such departures are, of cours, aimed at overcoming conceptual criticisms often levied at attempts to apply Leontief systems in such contexts.

That Wood and his associates have not entirely surmounted the overwhelming data difficulties characteristically encountered in such efforts is indicated by extensive reliance (in 1965) on overage data -- e.g., on World War II records -- to ascertain capital-output relationships.

The development of PARM constitutes a major learning experience in the evolution of recuperation models, and the prototype version that is described in this article will doubtless long be a point of reference if successor models with such detail are to be designed and used. The PARM activity per se has, however,

reportly ceased, and the model itself has been abandoned in favor of other which are relatively easier to exercise.

# SECTION III

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